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Tank Farm Contractor Operation and Utilization Plan

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Key Words: Phase 1 Privatization, Phase 2 Privatization, pretreatment, low-activity waste, high-level waste, SST retrieval sequence, and feed envelopes.

Abstract: This document updates the operating scenario and plans for feed delivery to BNFL Inc. of retrieval and waste from single-shell tanks, and the overall process flowsheets for Phases 1 and 2 of the River Protection Project. The plans and flowsheets are updated with the most recent guidance from ORP and tank-by-tank inventory. The results provide the technical basis for the RTP-2 planning effort. Sensitivity cases were run to evaluate the effect of changes on key parameters.

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ABSTRACT

The U.S. Department of Energy Office of River Protection is responsible for conduct and oversight of the River Protection Project (RPP). The RPP mission is to store, treat, immobilize, and dispose of the highly radioactive Hanford Site tank waste (including current and future tank waste and cesium and strontium capsules) in an environmentally sound, safe, and cost-effective manner. This document, which has been prepared by CH2MHILL Hanford Group, Inc., the Office of River Protection's Hanford Site Tank Farm Contractor (TFC), is the *Tank Farm Contractor Operation and Utilization Plan* (TFC O&UP). The TFC O&UP describes technical results from evaluating different scenarios for retrieving waste from the double-shell tanks and single-shell tanks, staging, delivering, treating, immobilizing, storing, and disposing of the tank waste, and possible impacts for accomplishing the RPP mission.

The constraints, assumptions, data inputs, results, findings, and other information reported in the TFC O&UP are organized into three main documents: a TFC O&UP Summary, which is intended primarily for use by headquarters and other senior decision makers; the TFC O&UP, Volume I, which is intended primarily for use in developing technical and programmatic planning information; and, the TFC O&UP, Volume II, which is intended primarily for use by engineers, scientists, and other technical personnel for use in preparing and managing data about waste processing. The purposes and structures of these documents are outlined below.

TFC Operation and Utilization Plan Summary

The purpose of the TFC O&UP Summary is to provide a broad overview of the objectives, functions, and results of the TFC O&UP, and to replace what would typically be presented in an Executive Summary. This summary document describes how the TFC O&UP supports tank waste retrieval and disposal planning, what information is needed, and what results are provided. It also summarizes the results for the principal waste processing scenario reported in the current revision of the TFC O&UP, and discusses comparative results for alternative cases used to assess planning sensitivities. The summary targets non-Hanford Site readers.

TFC Operation and Utilization Plan, Volume I

The TFC O&UP, Volume I, provides the technical details that describe, evaluate, and compare the results for various waste processing scenarios. Sensitivity analyses are included to assess RPP mission impacts associated with changes in assumptions, constraints, or other key parameters. Volume I is geared for a technical audience familiar with Hanford Site issues.

TFC Operation and Utilization Plan, Volume II

The purpose of Volume II of the TFC O&UP is to document key data, parameters of interest, and other information that are direct inputs and outputs for the computer simulation models and supporting calculations. Volume II provides a record repository and performs a configuration management role for the raw materials used to develop the results and findings presented in Volume I. Volume II is not generally distributed and is useful primarily for a reader researching background material.

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TANK FARM CONTRACTOR OPERATION AND UTILIZATION PLAN SUMMARY

S1.0 BACKGROUND

Approximately 204,400 m^3 (54 Mgal) of highly radioactive waste have accumulated in 177 large underground tanks at the Hanford Site. Approximately 3,800 m^3 (1 Mgal) of waste have leaked into the ground from 67 of the tanks. All tanks are close to or have exceeded their design lives. Radionuclides from past tank leaks have moved through the soil and now have reached the groundwater that flows under the Hanford Site and into the Columbia River, approximately seven miles away. To address this threat to the Columbia River, the U.S. Department of Energy (DOE) established the River Protection Project (RPP). DOE's Office of River Protection (ORP) is responsible for conduct and oversight of the RPP. The RPP mission is to store, treat, immobilize, and dispose of the highly radioactive Hanford Site tank waste (including current and future tank waste and cesium and strontium capsules) in an environmentally sound, safe, and cost-effective manner.

This document has been prepared by CH2MHILL Hanford Group, Inc. (CHG), the Hanford Site Tank Farm Contractor (TFC), to summarize the *Tank Farm Contractor Operation and Utilization Plan* (TFC O&UP). The TFC O&UP is a key technical baseline document that describes technical aspects of retrieving waste from the underground tanks and the results from treating and immobilizing tank waste to accomplish the RPP mission. The TFC O&UP uses computer-based simulations and calculations to evaluate proposed waste retrieval and processing scenarios. The TFC O&UP relies on tank waste inventory data to determine physical and chemical characteristics of tank waste liquids and solids. This and other information are used to model storage, retrieval, staging, delivery, immobilization, and immobilized waste product handling processes. Modeling results include estimates of as-delivered waste feed quantities and compositions, waste loading efficiencies for the immobilization processes, and quantities and composition of immobilized waste products. Outputs from the models and calculations can be used to verify the adequacy of waste feed delivery systems and components, schedules for retrieval and waste processing, and adequacy of tank waste storage and immobilized waste management capacities. The TFC O&UP documents these modeling and calculation efforts, reports the results and findings, and evaluates the impacts of different waste processing scenarios for the RPP mission.

S1.1 THE RIVER PROTECTION PROJECT

In 1989, DOE, the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology) entered into an enforceable compliance agreement (Ecology et al 1996) (commonly called the Tri-Party Agreement) that set milestones for cleanup of the tank waste. In 1996, in accordance with the *National Environmental Policy Act*, DOE and Ecology issued the *Tank Waste Remediation System Final Environmental Impact Statement* (DOE 1996), which assessed the full range of reasonable alternatives for continued safe management and remediation of the wastes. DOE subsequently issued a Record of Decision

(62 FR 8693) which documented the selection of a “Phased Implementation” alternative. Ecology concurred in the selection of this alternative.

The Phased Implementation alternative (as currently defined) consists of two major phases of work for retrieving and immobilizing the double-shell tank (DST) and single-shell tank (SST) wastes and closing the tank farms:

- Phase 1 is an initial production phase, lasting until about 2018, during which the efficiency and effectiveness of the processes selected to treat the tank waste will be verified. The Phase 1 effort includes treatment of an initial “Minimum Order” quantity (which could be completed as early as 2012) and treatment of an “Extended Order” quantity if the initial effort is successful. BNFL Inc. is the privatization contractor (ORP 1999) currently responsible for the Phase 1 treatment and immobilization facilities. CHG is currently responsible for retrieving and delivering tank waste feed to the treatment and immobilization facilities, and for accepting, storing, and disposing of the immobilized waste product.

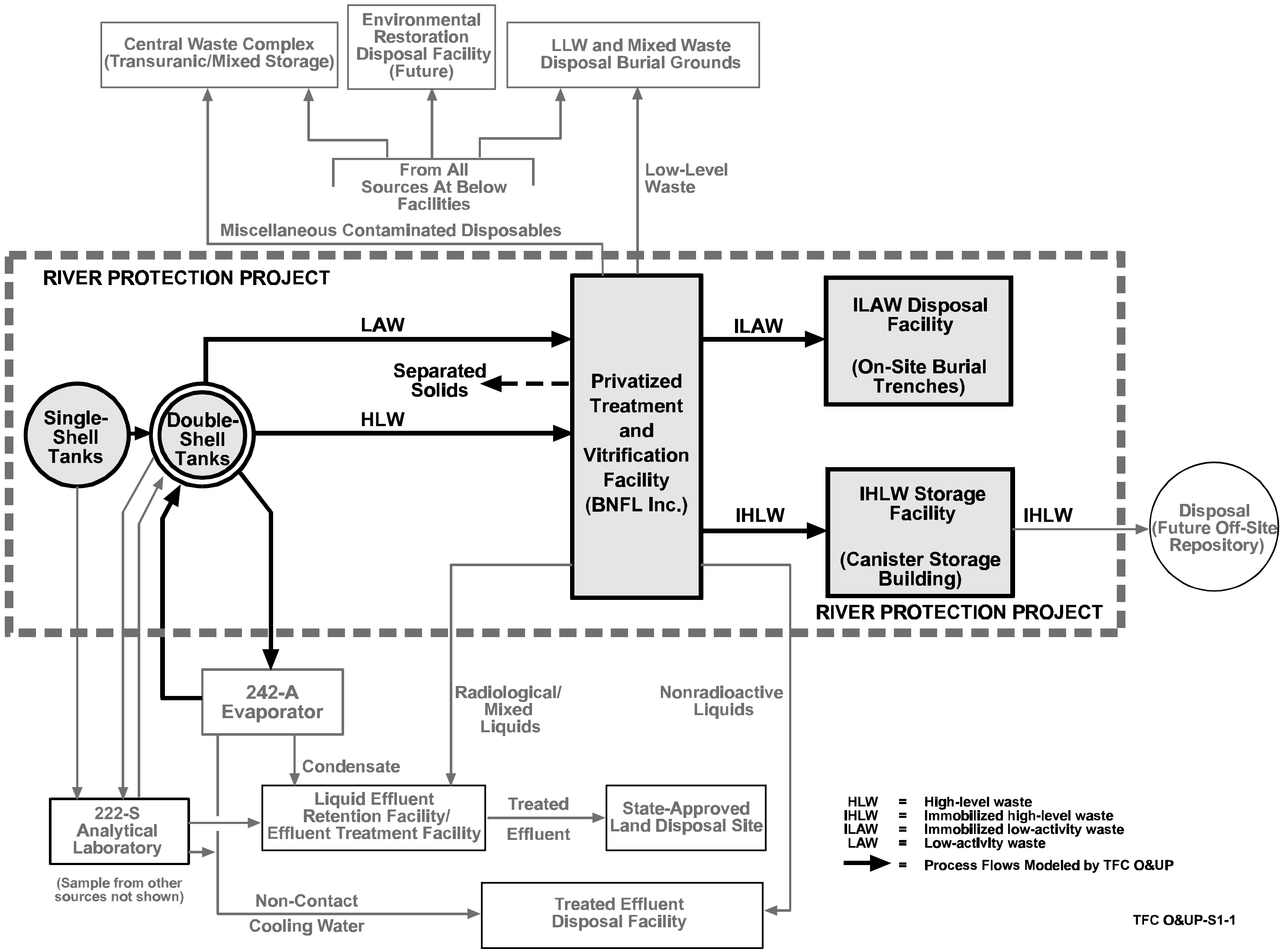
- Phase 2 is the full production phase when the majority of the waste will be treated. Phase 2 concepts include: scaling up of the treatment and immobilization facilities; transfer of SST wastes via waste receiving facilities into the DSTs for staging and delivery; final disposition of the immobilized products; closure (currently expected to be closure in-place) of emptied SSTs and then DSTs; and, transfer of the closed facilities to the Hanford Site cleanup program for long-term care and monitoring.

Most of the Phase 1 waste feed will originate in DSTs, with a relatively small contribution from selected SSTs (these transfers will help develop SST retrieval and closure technologies for use during Phase 2). Four different types of waste, will be processed in Phase 1 to demonstrate the viability of the waste treatment and immobilization processes. Low-activity waste (LAW) will be processed in three categories (designated Envelopes A, B, and C), and high-level waste (HLW) will be processed in one category (designated Envelope D). The treatment and immobilization processes being designed at this time rely on converting LAW and HLW into stable glass forms in a privately operated waste vitrification system. Immobilized low-activity waste (ILAW) will be disposed in near-surface disposal sites (to be constructed), and immobilized high-level waste (IHLW) will be stored in the existing Canister Storage Building (to be modified) and other facilities until shipment off-site. The major facilities and process flows associated with tank waste retrieval and disposal are depicted in Figure S1-1; the RPP components and the process flows addressed in the TFC O&UP are highlighted for clarity.

S1.2 PURPOSE OF THE TFC O&UP

Future tank waste remediation decisions require a thorough understanding of the operation and utilization of the SST, DST, treatment, storage, and disposal systems. The ability to easily consider and evaluate different tank waste retrieval and disposal scenarios is critical to designing optimal technology, environmental, cost, and schedule solutions for the RPP. To support this ability, ORP has directed its contractors to develop and maintain the TFC O&UP. Modeling and analyses of different waste processing scenarios is ongoing throughout the year, and the TFC O&UP is updated about annually to document and report current findings.

Figure S1-1. Major Facilities and Process Flows Associated with Tank Waste Retrieval and Disposal.



The TFC O&UP documents how information, engineering calculations, process models, and other capabilities have been developed and used to evaluate current RPP requirements and guidance on tank waste retrieval, treatment, storage, and disposal. Each update of the TFC O&UP describes the most current tank waste processing simulations, inputs to the simulations, limitations of the information and data used, and necessary assumptions. The TFC O&UP also describes and interprets the results of these simulations with respect to potential impacts on the RPP life-cycle, discusses the sensitivity of the results to changing conditions, makes recommendations for future improvements, and addresses other significant considerations. Thus, the TFC O&UP fulfills two main purposes:

- It defines the engineering tools and input data used to test different waste processing scenarios. The TFC O&UP provides a coherent methodology for integrating and evaluating the effects of varying waste properties, schedules, technologies, and other process constraints. The result is a consistent, defensible means by which managers and decision makers can compare, control, and optimize the technical baseline for those factors that significantly influence tank waste retrieval and disposal capabilities.

- It provides an engineering record of the work performed to define, test, and evaluate different waste processing scenarios. The TFC O&UP ensures that technical baseline planning efforts conducted to date are traceable and reproducible, and documents the technical baseline history as new events and information are accounted for. The TFC O&UP provides ongoing confirmation of the validity of the evolving plans for processing tank wastes and current recommendations derived from the scenario evaluations. The result is a continuously improving level of confidence that a credible plan, with a reasonable chance of success, has been devised and can be implemented for tank waste retrieval and disposal.

The TFC O&UP consists of this summary document, and Volumes I and II, which provide the complete engineering and technical details used to develop and evaluate alternative tank waste processing scenarios. Section S2.0 of this summary document describes how the TFC O&UP supports tank waste retrieval and disposal planning, what information is needed, and what results are provided. Section S3.0 summarizes the results for the principal waste processing scenario reported in the current revision of the TFC O&UP, and discusses comparative results for alternative cases used to assess planning sensitivities. Attachment 1 provides a section-by-section annotation of the TFC O&UP, Volumes I and II, and Attachment 2 presents sample calculations used to test and establish the reliability of the model results developed in the TFC O&UP.

S2.0 INTRODUCTION TO THE TFC O&UP

The TFC O&UP is an engineering document that analyzes key information and data and models the dynamic relationships between current and future tank waste operations. It provides a variety of calculations and other results that are used to evaluate different waste processing scenarios. This section explains how TFC O&UP helps support planning for tank waste retrieval and disposal, identifies the types of information and data needed to evaluate waste processing scenarios, and briefly describes the types of results provided by the TFC O&UP models and calculations. (Note that actual results and findings for the current revision of the TFC O&UP are discussed in Section S3.0.) This section provides information at a summary level; Volumes I and II of the TFC O&UP should be consulted for source details.

S2.1 HOW TFC O&UP SUPPORTS TANK WASTE RETRIEVAL AND DISPOSAL PLANNING

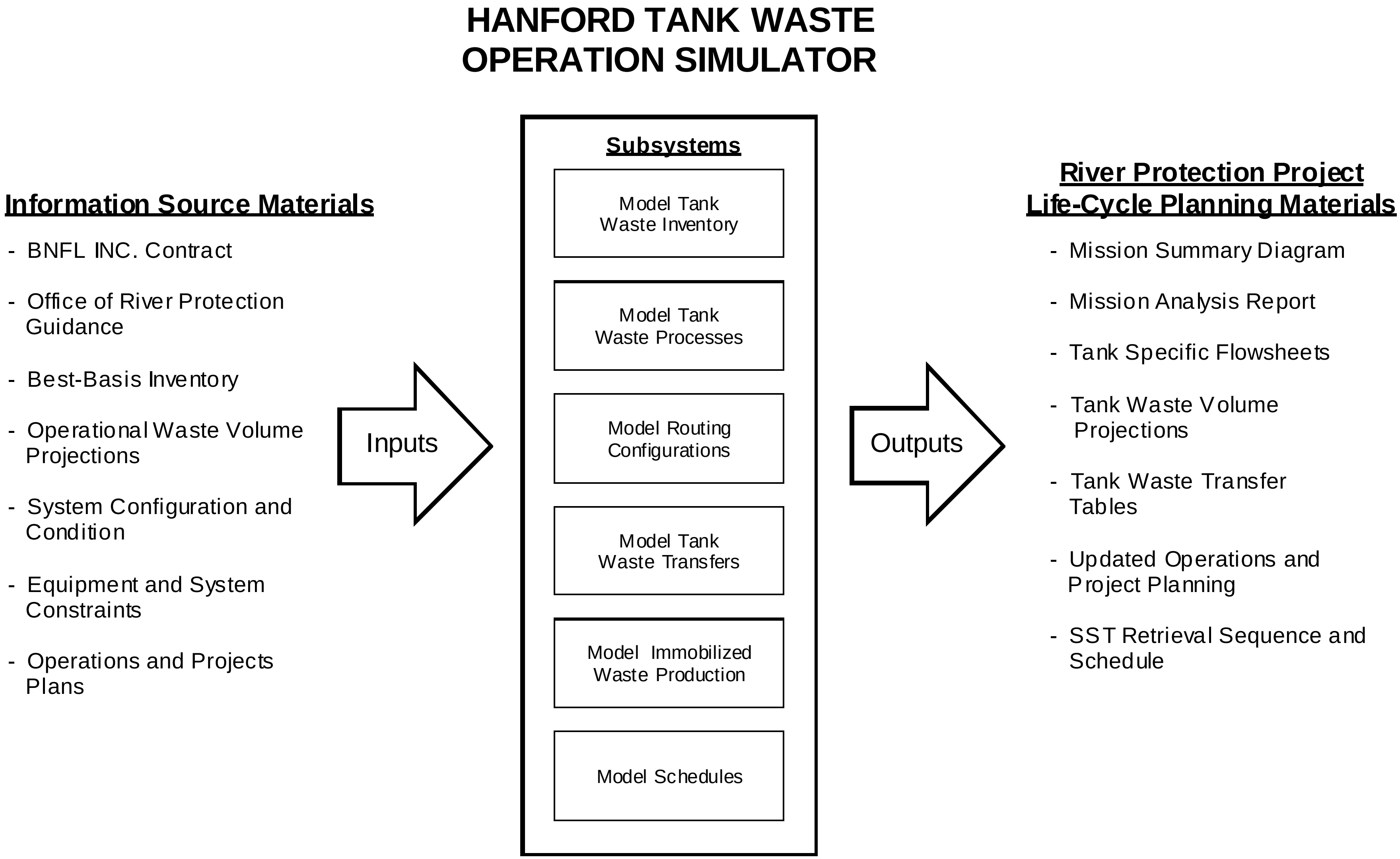
The TFC O&UP uses information about waste properties, tank system configurations, desired end states, target milestones, and other parameters associated with particular waste processing scenarios, to produce a variety of outputs, such as spreadsheets, figures, tables, and schedules. These outputs are used to evaluate the relationship between tank waste retrieval and disposal activities and the overall ability to accomplish the RPP mission. Much of this information is used to describe and bound existing and projected conditions for the major operating facilities and process flows within the RPP.

The principal tool used to perform the analyses and provide the results documented in the TFC O&UP is a computer-based model called the Hanford Tank Waste Operation Simulator (HTWOS). The HTWOS calls on several other models and computational subroutines to process data, simulate operating scenarios, perform chemical- and mass-balance calculations, and derive time estimates and processing schedules. Figure S2-1 provides a functional block diagram showing the main subsystems that support HTWOS, along with key sources from which input information is obtained, and key technical and program materials that use the outputs from HTWOS. Typical HTWOS tank waste processing simulations involve the following steps.

Establish the Characteristics of Source Tank Wastes

- **Produce Source Tank Inventory**. An accurate inventory of the parameters of interest for the waste in a source tank is needed before it is possible to determine whether applicable limits (e.g., envelope specifications, safety licenses, environmental permits) can be met during waste retrieval and upon delivery of waste feed to the treatment and immobilization facility. Information about tank waste is derived from the Best-Basis Inventory, which incorporates sample analytical data, process knowledge, and historical transfer data to compile and calculate tank-specific inventories for waste constituents, quantities, properties, and other parameters of interest. These parameters are partitioned between the liquid and solid phases of the source tank waste to produce the source tank waste inventory used by the HTWOS.

Figure S2-1. Functional Diagram of HTWOS Subsystems, Input Sources, and Output Materials.



- **Calculate Liquid Fraction (Supernate)**. Both DST and retrieved SST waste will be comprised primarily of a liquid fraction, or supernate, and a solid fraction, or sludge. The HTWOS receives the tank inventory input data for the supernate portion and adjusts for the effects of interstitial liquid (between sludge particles) and entrained solids (small particles that remain suspended in the liquids). The model then calculates how much source tank waste is available as supernate, and how the parameters of interest (primarily chemical and radionuclide constituents) are distributed in the supernate. This information is subsequently combined with the sludge calculations from the next step to produce an "as is" composition for the source tank waste.

- **Calculate Solids Fraction (Sludge)**. In most cases, source tank sludge will consist of a mixture of solids (soluble and insoluble) and interstitial liquid. The HTWOS receives the tank inventory input data for the sludge portion and adjusts the data using wash factors (to allocate the soluble sludge components to the interstitial liquid) and entrainment factors (to determine which sludge components occur as interstitial liquids between sludge particles and which as entrained solids). The model then calculates how the source tank waste is present as interstitial liquids between sludge particles, entrained solids, and sludge, and how the parameters of interest are distributed in these phases. This information is combined with the preceding supernate calculations to produce the "as is" composition for the source tank waste.

<u>Model Tank Waste Storage, Retrieval, and Delivery</u>

- **Model Storage and Decanting.** The HTWOS model accounts for the effects of different processes (e.g., gas releases, evaporation losses) that occur during long-term storage of waste in a source tank and adjusts the tank waste inventory accordingly. The HTWOS then models the decanting process for removing supernate from the source tank, calculating the quantities and inventory of constituents that leave the source tank with the supernate, and what components remain in the source tank as part of the sludge "heel." This inventory information is used in the next two steps to determine the composition of the feed delivered to the treatment and immobilization facility.

- **Model Delivery of LAW Supernate**. The HTWOS models the process for retrieving, transferring, staging, and delivering decantable supernate from the waste feed source tank to the treatment and immobilization facility. The HTWOS accounts for the effects of homogenizing the waste with mixer pumps, various water additions to support transfer (e.g., dilution water, pipeline flush water), and other process effects (e.g., staging in interim tanks). The HTWOS then calculates the tank waste quantity and composition "as delivered" to the treatment and immobilization facility, and calculates what residual waste remains behind as non-retrievable "heel." If a tank is being reused as a staging tank, the HTWOS calculates the quantity and composition of the combined "heel" and the added tank wastes. Similar "heel" calculations are also performed in the next two modeling steps.

- **Model Dissolution of Soluble Sludge and Delivery of LAW Supernate**. For specific tanks, the HTWOS models the process for dissolving soluble components of the sludge remaining in the waste feed source tank, then transferring, staging, and delivering the consequent supernate to the treatment and immobilization facility. The HTWOS accounts for the effects of adding liquids and dissolving solids, homogenizing the waste with mixer pumps, and various other water additions (e.g., pipeline flush water) and process effects (e.g., interim staging). The HTWOS then calculates the tank waste quantity and composition "as delivered" to the treatment and immobilization facility. The HTWOS performs calculations, similar to those described above, to determine the impacts of residual "heels".

- **Model Mobilization and Delivery of HLW Sludge**. The HTWOS models the process for mobilizing HLW sludge, staging the sludge (sometimes as a mixture with other tank sludges), and remobilizing the sludge and delivering the resulting HLW feed to the treatment and immobilization facility. The HTWOS accounts for various water additions, and for the efficiency of mixer pumps, sluicers, and other waste retrieval technologies to mobilize and/or retrieve the waste from a HLW source tank. The HTWOS then calculates the tank waste quantity and composition "as delivered" to the treatment and immobilization facility and solids loading in the delivered slurry. The HTWOS performs calculations, similar to those described above, to determine the impacts of residual "heels."

<u>**Model Tank Waste Immobilization, Storage, and Disposal**</u>

- **Model Generation of Immobilized Waste Products**. The HTWOS models the process for converting the LAW and HLW feeds to immobilized (glass) products. The HTWOS employs a subroutine that predicts the waste loading in the glass and the resulting volume of waste glass produced. (Although this subroutine accounts for some information from BNFL Inc., the resulting predictions do not represent actual BNFL Inc. contract commitments.) The volumes of ILAW and IHLW glass are divided by the effective volumes of ILAW and IHLW containers to estimate the number of products of each type that must be stored or diposed.

- **Model Immobilized Waste Product Storage and Disposal**. The HTWOS models the generation rate of glass products. Comparisons of the availability of planned ILAW disposal capacity and planned IHLW storage capacity are used to evaluate the required disposal and storage facilities and identify if changes to current plans are needed.

The HTWOS processing simulations, described above, provide critical information (e.g., "as is" and "as delivered" waste feed compositions and quantities) needed to plan waste retrieval, treatment, immobilization, and disposal. Other subsystems of the HTWOS provide the TFC O&UP with additional information needed for program and project planning, including the following.

- **Routing Configurations**. The TFC O&UP helps verify planned tank farm system configurations (e.g., transfer lines, interim staging tanks, pumps) for routing tank wastes from retrieval to delivery. In effect, the HTWOS models all waste movements within the physical system needed to accomplish waste feed delivery. The time-dependent effects of and requirements for addressing dilution, residual heel additions, settling and precipitation, physical properties, and other critical waste parameters are accounted for in the HTWOS modeling and calculations. This information can help confirm the technical and schedule viability of planned routing configurations and/or highlight potential anomalies or areas of concern for further attention.

- **Process Schedules**. The HTWOS calculates timeframes and develops schedule models for retrieving, staging, and delivering tank waste, and return of immobilized waste products for disposal or storage. System failures and other impacts, such as construction outages, can be modeled to assess effects on delivery and processing schedules. This information can be used to determine "start to finish" timelines, establish interim milestones, and assess the feasibility of delivering wastes in accordance with the contract schedule requirements being established in the ORP and BNFL Inc. contract (ORP 1999). This information also helps CHG coordinate project schedules for building and upgrading the facilities and infrastructure needed to deliver tank wastes, support BNFL Inc., and manage immobilized waste products.

- **DST Space Management**. The TFC O&UP uses HTWOS to develop information about how space in the DSTs would be utilized during the RPP life-cycle, accounting for the effects of waste retrieval, staging, and delivery. This information can be used to evaluate whether sufficient capacity exists, how to optimize use of this capacity for achieving the RPP mission, and potential impacts of significant events that could cause capacity reductions (e.g., one or more tank primary containment failures).

Information that serves as key inputs to the TFC O&UP must be collected, verified, compiled into formats compatible for data processing, and distributed to the appropriate models and calculation subroutines. Section S2.2 describes the input information needed. Key output information must be validated, assessed for potential limitations, and compiled into formats that are useful to planners, managers, and decision makers. Section S2.3 describes outputs and results provided by the TFC O&UP.

S2.2 INFORMATION SOURCES FOR TFC O&UP – KEY INPUT PARAMETERS

Technical information used to support the TFC O&UP is obtained from a variety of sources that range from large relational databases, to consensus standards in the scientific literature, to peer-reviewed engineering studies, to specialized laboratory and bench-scale tests. Sources for technical information are cited throughout the TFC O&UP, Volumes I and II, and noted in the references section. Of the many sources drawn upon, the following are of particular note:

- **Hanford Best-Basis Inventory**. The Best-Basis Inventory (Kupfer et al. 1999, and Tank Waste Information Network System) provides tank-specific and total tank (global) estimates for chemical and radionuclide components and waste characteristics in the 177

Hanford Site SSTs and DSTs. Tank-by-tank inventories include 25 chemical and 46 radionuclide components for each of the SSTs and DSTs. The global waste inventories include five additional chemicals and provide an independent estimate of the total amount of each chemical or radionuclide component presently stored in the tanks. The chemical analytes selected represent over 99 weight percent of the tank contents and the radionuclides represent over 99 percent of the radioactivity. Information used to establish global inventories originated from key historical records (e.g., essential material purchase records), from various chemical flowsheets used in reprocessing of irradiated Hanford Site reactor fuels, and from calculations of radionuclide isotope generation and decay. Tank-by-tank inventories are most often based on sample analysis results. All updates to tank data are reviewed and approved with appropriate documentation. Issuance of the data is provided in Tank Characterization Reports and all data are entered into the Tank Characterization Database. Global and tank-by-tank inventories serve as waste composition data for RPP process flowsheet modeling work, safety analyses, risk assessments, and waste retrieval, treatment, and disposal system design.

- **Operational Waste Volume Projection**. The Operational Waste Volume Projection (Strode and Boyles 1999) presents a basis for evaluating future DST space needs through 2018. It relies on a computer simulation of site operations to estimate tank usage for three alternative cases, compares the projected tank space needs for the three cases, and describes the estimated differences and space saving alternatives. All three cases incorporate anticipated effects of the Phase 1 privatized waste retrieval and immobilization strategy. For purposes of consistency and configuration management, the same computer simulation model (i.e., HTWOS) is used to prepare the Operational Waste Volume Projection. The Operational Waste Volume Projection is updated at least annually with the latest DST storage information, and is used to generate projections of tank fill schedules, tank transfers, evaporator operations, tank waste retrievals, and aging-waste tank usage. Potential requirements for new DST construction, tank waste retrievals, facility schedules, waste generation reductions, Tri-Party Agreement milestones, and funding priorities can be reviewed in relation to the tank space availability projections.

- **SST Pumpable Liquid Volume Estimates**. The SST liquid estimates (Field and Vladimiroff 1999) are prepared in support of efforts to interim stabilize the SSTs by removing pumpable liquids and thus reducing leakage potential. Fewer than 30 SSTs still contain pumpable liquids, but they are projected to contribute approximately four million gallons of liquid wastes to the DSTs over the next five years. The liquid volume estimates are based on various tank- and waste-specific parameters, such as tank waste volume estimates; measured liquid levels; drainable porosity estimates; capillary height; unpumpable regions; and, pumping rates. A volume range has been estimated to reflect potential uncertainties in some of the assumptions about the tank waste characteristics, and the SST pumpable liquid volume estimates are updated as needed to incorporate new and changed data.

- **Waste Feed Delivery Technical Basis**. The waste feed delivery technical basis is part of the RPP technical baseline, and has been developed to ensure a consistent and wellconfigured technical approach to tank waste retrieval, staging, and feed delivery. The technical basis describes the set of technical analyses and requirements, science and engineering documentation, equipment, facilities, materials, qualified staff, and operating procedures needed to start up and complete the waste feed delivery objectives of the RPP mission. The technical approach and data for waste feed delivery are defined in three concept documents: the process flowsheets, the waste feed delivery system description, and the operations and maintenance concept. The process flowsheets outline the feed staging and delivery process, provide material and energy balance, and define detailed process flow information for each source tank and waste batch transfer. The system description describes the physical tank farm infrastructure needed to support waste feed delivery, including the existing systems and components in the tank farms, and the systems and components being designed and constructed by various projects to complete the required retrieval, staging, and delivery system. The operations and maintenance concept describes the operational activities needed to accomplish waste feed delivery, and provides the methodology and process to identify, assess, and evaluate operations and maintenance risks within the waste feed delivery system.

Technical information sources, such as those noted above, are considered to be relatively stable and changes that could occur to this information are, with a few exceptions, not expected to significantly alter the HTWOS calculations and modeling results. Moreover, uncertainties or errors in this technical information are typically subject to correction by scientific or engineering means (e.g., laboratory analyses, field tests, trade studies), and changes are readily accomodated by the TFC O&UP with little or no interpretation or direction.

Other inputs to the TFC O&UP are based on programmatic information, such as overall project objectives, contractual agreements, regulatory commitments, expected (but not yet verifiable) technological designs and capabilities, and other planning assumptions. As the RPP matures over time, many programmatic inputs will stabilize and can be converted to technical information and data. In the meantime, changes to the TFC O&UP can be anticipated as programmatic inputs evolve. Key parameters used as programmatic inputs for the current revision of the TFC O&UP are provided below and in Table S2-1. These parameters are based on current (through March 8, 2000) Project Integration Office (PIO) guidance (PIO 2000), and are documented in Volume II, Appendix A, and other relevant sections of the TFC O&UP.

- Design basis for sodium oxide loadings in ILAW glass are 19.5 percent by weight (wt%) for Envelope A, 7.5 wt% for Envelope B, and 17.0 wt% for Envelope C.

- Design basis for waste oxide loading in IHLW glass is the Battelle Pacific Northwest National Laboratory “Glass Properties Model.”

- Nominal vitrification rates are based on an average of 2.38 LAW packages/day and 0.28 IHLW canisters/day.

- Glass density is 2.66 metric tons (MT)/m^3, with an average of 6.0 MT of ILAW/package and 3.1 MT of IHLW/canister

- Immobilized glass product deliveries to CHG start when BNFL Inc. lag storage is 50 percent full for ILAW, and 50 percent full for IHLW.

- Minimum Order quantity for LAW processing is 6,000 units, and for HLW processing is 600 canisters.

- Phase 2 waste immobilization begins in 2018 and is completed in approximately 2030.

- During Phase 2, DSTs will fail at a rate of one for each five years past design life. Replacements will be constructed as required. Volume and transfer capacity equivalent to the existing DST system is assumed to be available through Phase 2.

- Phase 2 treatment will consist of two facilities, and processing capacities will increase to 120 MT and 12 MT of glass per day for ILAW and IHLW, respectively.

- Phase 2 SST Retrieval

  - SSTs are retrieved in a sequence driven by the objective to reduce long-term human health and environmental risk to the extent possible.

  - SST wastes are retrieved at a rate consistent with the rate that space is made available in DSTs by treating and immobilizing waste staged in the DSTs.

  - The rate of retrieval for SST waste is also consistent with historical rates achieved using past practice sluicing.

Table S2-1. Key Phase 1 Programmatic Input Parameters.[a]

Key Schedule Milestone Parameters		
Initiate Pretreatment Hot Start	4/30/06	
First LAW Batch Delivery[b]	4/30/06	
First HLW Batch Delivery[b]	10/31/06	
Second HLW Batch Delivery[b]	3/31/08	
Second LAW Batch Delivery[b]	2/28/09 (Earliest)	
End of Privatization Phase 1	February 2018	
Key Waste Feed Delivery Rate Ramp Up Parameters		
LAW Feed Delivery Ramp Up[c]	From – To	Units[d]
	11/30/06 – 11/30/07	278 (37%)
	11/30/07 – 11/30/08	832 (110%)
	11/30/08 – 11/30/09	1,012 (134%)
	Through Minimum Order	1,100 (146%)
	Through Extended Order	1,100 (146%)
HLW Feed Delivery Ramp Up[e]	From – To	No. of Canisters
	8/31/08 – 8/31/09	41 (40%)
	Through Minimum Order	120 (118%)

	Through Extended Order	120 (118%)

[a]Based on Project Integration Office guidance (through March 8, 2000) (PIO 2000).

[b]Dates shown are for completion of delivery; start of delivery is two months prior to completion.

[c]LAW rates are given as units of waste processed during a 12-month period and (in parentheses) as a percentage of BNFL Inc.'s nominal annual capacity (754 units/year).

[d]The term "unit" reflects the difficulty of processing LAW feed. One metric ton of elemental sodium contained in LAW Envelopes A, B, and C waste feed is equivalent to 1.0, 2.6, and 1.15 units, respectively.

[e]HLW rates are given as canisters of glass produced during a 12-month period and (in parentheses) as a percentage of BNFL Inc.'s nominal annual capacity (102 canisters/year).

The body of the TFC O&UP describes input parameters as well as secondary or derivative assumptions and constraints that were developed to apply these parameters in the HTWOS model (see TFC O&UP, Volume II, Appendix A for detailed documentation of these parameters, constraints, and assumptions). The alternative scenarios evaluated in the TFC O&UP are based primarily on varying some of the above parameters to evaluate program and project impacts relative to current planning.

S2.3 OVERVIEW OF THE TFC O&UP RESULTS

The results of the TFC O&UP are, primarily, informational representations and depictions that have been developed to compile and enhance the meaning of the technical data outputs produced by the HTWOS models and calculations. These representations and depictions are used by planners, managers, and decision makers for evaluating the impacts of different tank waste processing scenarios on the ability to achieve the RPP mission. The rest of this section briefly outlines some key results provided by the TFC O&UP and their relation to the HTWOS outputs.

The HTWOS provides various types of data and information outputs at numerous stages during each simulation run. More than 200 separate computer data files and records are generated in conjunction with conducting a typical HTWOS model scenario. Table S2-2 provides a sample printout of some of the file names for data sets and records produced by the HTWOS model and calculations. Note that the listed examples are provided only to demonstrate the extent and complexity of the HTWOS modeling and calculation processes; the files listed should not be interpreted as representative or typical of any particular HTWOS scenario evaluations.

Table S2-2. Example List of Output Files Produced by the HTWOS.[a]

EAST-RECEIPT-feed-tank-history.his	STAGING-feed-tank-history.his	HLW-WASH-SOLUTION-total-current-kgs
EAST-RECEIPT-total-current-kgs	STAGING-total-current-kgs	HLW-WASH-SOLUTION-total-input-kgs
EAST-RECEIPT-total-input-kgs	STAGING-total-input-kgs	HLW-WASH-SOLUTION-total-moved-kgs
EAST-RECEIPT-total-moved-kgs	STAGING-total-volume-history.his	
EAST-RECEIPT-total-volume-history.his	STAGING-transfers-in-history.his	HLW-GLASS-PLANT-feed-tank-history.his
EAST-RECEIPT-transfers-in-history.his		HLW-GLASS-PLANT-total-current-kgs
	LAW-STAGING-to-DILUTE-RECEIVERS	HLW-GLASS-PLANT-total-input-kgs
WEST-REC-1-feed-tank-history.his	LAW-STAGING-to-ENTRAINED-SOLIDS	HLW-GLASS-PLANT-total-moved-kgs
WEST-REC-1-transfers-in-history.his	LAW-STAGING-to-LAW-RECEIPT	

Table S2-2. Example List of Output Files Produced by the HTWOS.[a]

WEST-REC-2-feed-tank-history.his	LAW-STAGING-total-current-kgs	HLW-RECYCLE-total-current-kgs
WEST-REC-2-transfers-in-history.his	LAW-STAGING-total-input-kgs	HLW-RECYCLE-total-input-kgs
WEST-REC-3-feed-tank-history.his	LAW-STAGING-total-moved-kgs	HLW-RECYCLE-total-moved-kgs
WEST-REC-3-transfers-in-history.his		
	ENTRAINED-SOLIDS-total-current-kgs	LAW-GLASS-PLANT-feed-tank-history.his
X-SITE-REC-feed-tank-history.his	ENTRAINED-SOLIDS-total-input-kgs	LAW-GLASS-PLANT-total-current-kgs
X-SITE-REC-total-current-kgs	ENTRAINED-SOLIDS-total-moved-kgs	LAW-GLASS-PLANT-total-input-kgs
X-SITE-REC-total-input-kgs		LAW-GLASS-PLANT-total-moved-kgs
X-SITE-REC-total-moved-kgs	SLUDGE-WASH-feed-tank-history.his	
X-SITE-REC-total-volume-history.his	SLUDGE-WASH-total-input-kgs	LAW-RECYCLE-total-current-kgs
X-SITE-REC-transfers-in-history.his	SLUDGE-WASH-total-moved-kgs	LAW-RECYCLE-total-input-kgs
		LAW-RECYCLE-total-moved-kgs
MONTHLY-BATCHES-total-current-kgs	WASHED-SOLIDS-feed-tank-history.his	LAW-RECYCLE-total-volume-history.his
MONTHLY-BATCHES-total-input-kgs	WASHED-SOLIDS-total-input-kgs	
MONTHLY-BATCHES-total-moved-kgs	WASHED-SOLIDS-total-moved-kgs	WATER-monthly-output.his

[a]Randomly selected sampling from more than 200 separate output files and data records.

Some output files are used solely as inputs to other information-processing subroutines within the HTWOS, while others capture time-dependent “snapshots” of specific tank farm or waste processing conditions, predict future trends and circumstances, or compare predicted versus desired end-states. In many cases, outputs from several file sets are compiled together to create different formats and presentations of the information. These various “raw” and interpreted data outputs provide the bases for the results reported in the TFC O&UP. Following is a summary of TFC O&UP results that have been found by many program and project decision makers to have broad utility for planning, scheduling, and estimating purposes.

- **Mission Summary Diagrams**. Mission summary diagrams summarize schedule interfaces between Phase 1 project activities and the need dates driven by the Phase 1 feed staging, delivery, and processing scenarios. The diagrams help with identifying, integrating, and optimizing Phase 1 schedules for facility upgrades and construction; waste retrieval, delivery, certification, and processing; and immobilized product returns, storage, and disposal. The diagrams indicate where schedule dependencies, available “free” time (referred to as schedule “float”), and overlaps exist. Among other uses, such information can help with decisions about efficient obligation and utilization of limited resources and funds. Key HTWOS outputs used to build the mission summary diagrams include: tank farm transfer schedules; treatment and immobilization processing schedules; and, selected waste/product mass-balance calculations.

- **Waste Feed Staging Plans**. Waste feed staging plans describe the sequence in which different batches of tank waste will be retrieved, staged, and delivered to the treatment and immobilization facility, along with a description of the actions (e.g., mixing, decanting, solids dilution) required to accomplish this sequence in accordance with contractual specifications for the waste feed compositions, quantities, and delivery rates and schedules. A proposed waste feed delivery approach is developed first to help structure inputs to and model components of the HTWOS. HTWOS outputs are then used to evaluate the viability of the proposed staging plan, and further refine the plan as necessary to account for equipment, schedule, and other results until fully acceptable waste feed staging plans are produced. Among other uses, waste feed staging plans are of particular importance for defining the scopes of work to be accomplished by projects and operations that support waste feed delivery. Key HTWOS outputs used to refine and evaluate waste feed staging plans include: tank farm transfer schedules; waste feed delivery schedules; waste feed volume estimates; projected waste feed compositions; and, waste feed envelope compliance comparisons.

- **DST Usage Allocation Diagrams**. A range of potential needs compete for the physical waste storage space available in the DSTs. The DST usage allocation diagrams show the dependent needs, and current and future commitments for space in the DSTs. The diagrams depict how DST storage capacity changes over time, impacts of construction and other in-farm work that constrain the ability to use particular tanks, and the effects of waste retrieval, staging, and feed delivery activities on tank usage. The DST usage allocation diagrams are used to help ensure that available capacity will not be exceeded, to optimize the efficiency with which the available space is used, and to evaluate potential scenarios associated with temporary or permanent losses of storage capacity. The HTWOS outputs used to develop the usage diagrams include, primarily: tank farm transfer schedules; waste feed delivery schedules; waste feed volume estimates; and DST volume plots.

- **System Performance Assessments**. System performance assessments are used to identify potential deficiencies in the ability of the current facilities, and planned upgrades, to support waste feed delivery and other requirements of the RPP mission. These assessments help operations and projects determine whether existing systems, structures, and components will function as required, whether known future upgrades include sufficient and correct work scope, and whether additional work is needed to repair, replace, or supplement tank farm facilities. The HTWOS outputs used to support these assessments include: waste transfer schedules; DST volume plots; DST usage allocation diagrams; and, project schedules.

- **Immobilized Waste Product Staging Plans**. Immobilized waste product staging plans describe the volumes and rates at which ILAW packages and IHLW canisters will be produced, along with information about the types, durations, and sequence of actions (e.g., transportation, acceptance, placement) required to receive and disposition the immobilized waste product in accordance with contractual requirements. The product staging plans are used to evaluate planned ILAW disposal capacity and planned IHLW storage capacity against projected capacity needs and schedules, and to help refine facility designs, construction schedules, and other plans accordingly. The HTWOS outputs used to develop these staging plans include: estimated ILAW quantity and composition; ILAW production schedules; estimated IHLW quantity and composition; IHLW production schedules; heat loading estimates; and, radionuclide content/dose estimates.

- **Required Equipment and Components Lists**. These lists are derived from the information (e.g., HTWOS outputs for waste staging and processing sequences for each tank) and assessments (e.g., system performance) described above. Once the requirements for and adequacy of existing systems and facilities has been evaluated, it is possible to produce a preliminary list of the equipment and components needed to ensure success of waste feed delivery and the RPP mission. Among other uses, these lists can help further define work scope for projects and operations, identify potential long-lead procurement items, and determine whether engineering or other studies may be needed to define component specifications. Key HTWOS outputs and TFC O&UP results used to develop equipment and components lists include: operations and project schedules; waste feed and waste product staging plans; and, system performance assessments.

- **Integrated Process Flowsheet**. An integrated process flowsheet is an anticipated future result of the TFC O&UP. Development depends on the availability of more complete information about the waste processing activities that will occur in the treatment and immobilization facility. As this information becomes available, it will be possible to devise a flowsheet to describe how tank wastes are processed from source to glass. This integrated process flowsheet will include essential information about waste chemical and radionuclide constituents, other significant waste parameters of interest, how these constituents and parameters are altered through the retrieval, staging, treatment, and immobilization steps, and how they finally are incorporated into the final ILAW packages and IHLW canisters. Among other uses, this information can help improve selection of waste feed sources, sequences, and schedules; refine the entire waste process for optimal loading of waste constituents in the glass products; identify opportunities to improve waste processing efficiencies through waste blending or similar actions; and, assist ORP in evaluating different compensation models for determining fair payments to BNFL Inc. (for processing wastes that do not satisfy all applicable specifications). Key HTWOS outputs that will be used to develop integrated process flowsheets include: waste feed volume estimates; projected waste feed compositions; estimated ILAW quantity and composition; estimated IHLW quantity and composition; heat loading estimates, radionuclide content, and dose estimates; and, selected waste/product mass-balance calculations

Many other results are currently available in the TFC O&UP, or can be developed using the data outputs and information generated for the TFC O&UP. Interested parties should contact the TFC O&UP authors and their managers regarding other types of results that may be useful for assessing tank waste retrieval and disposal activities and the ability to successfully support the RPP mission.

S3.0 KEY RESULTS AND FINDINGS OF THE TFC O&UP

The TFC O&UP is a dynamic document that is updated periodically (e.g., annually) to account for adjustments to the RPP mission and waste retrieval and disposal objectives. The TFC O&UP provides results and findings that are used for planning waste retrieval, feed delivery, processing, and disposition, and identifies possible sensitivities with current planning by analyzing the consequences of alternative scenarios.

The principal scenario reported in the current revision of the TFC O&UP is referred to in this summary document as the PIO Guidance Case.[1] Key input parameters and PIO guidance (PIO 2000) associated with this case were described previously in Section S2.2. This section summarizes key results and findings from the TFC O&UP for the PIO Guidance Case, and summarizes important planning sensitivities for several alternative scenarios. The TFC O&UP provides substantially more details than can be included here and should be consulted for more complete information.

S3.1 EVALUATION OF THE PIO GUIDANCE CASE

The PIO Guidance Case has grown out of a preliminary waste feed delivery approach that was developed as follows.

- First, initial sets of source tanks were identified to satisfy contractual requirements and ORP planning direction. The most recent inventories in these tanks were used to evaluate compliance with specifications for the waste feed envelopes (Envelopes A, B, and C for LAW; Envelope D for HLW).
- Next, the selected candidate source tanks and preliminary tank waste retrieval sequences were improved based on additional criteria (e.g., ease of retrieval, collocation of retrieval equipment) and more flexible waste staging strategies.
- Next, different retrieval, staging, and delivery approaches were iteratively tested using the HTWOS model to identify flaws, find opportunities for improvement, and integrate modeled process flows.
- Finally, ORP used the results of this preliminary work to provide guidance to CHG (PIO 2000) on the waste feed delivery approach (including waste source tanks and delivery sequence) that was applied in the TFC O&UP.

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[1]The PIO Guidance Case was modeled in the HTWOS and is identified within the body of the TFC O&UP as Case 3S6E. The different planning scenarios and sensitivity analyses are numbered to facilitate internal tracking and configuration control. Some of the figures, tables, or other materials in this summary may include references to Case 3S6E.

Principal conclusions of the TFC O&UP for the PIO Guidance Case are as follows.

- The PIO Guidance Case is viable and can be achieved within anticipated technical and schedule constraints.
- The PIO Guidance Case includes a Phase 1 waste retrieval and delivery sequence that provides sufficient margin for storing waste feeds with no apparent cost penalty to ORP. The case ensures low risk of idle vitrification facilities during Phase 1 by providing adequate staging and backup staging tank capacity.
- The current waste feed delivery projects planned for Phase 1 will (with some potential scope addition) support delivery of feed to BNFL Inc. within reasonable bounds of schedule float and conservative flowsheet assumptions.
- A reasonable Phase 2 waste retrieval and delivery sequence has been identified that optimizes retrieval strategy criteria (e.g., minimize public and environmental risks, maintain feed rates to keep immobilization facilities operating) under current known constraints.
- Immobilized glass product facilities are expected to be available in time and to have sufficient ILAW disposal and IHLW storage capacities for Phases 1 and 2. Design and construction schedules for the initial disposal and storage facilities may need to be accelerated (by up to six months) if BNFL Inc. processes waste at the maximum rates allowed in the ORP and BNFL Inc. contract (ORP 1999).

These conclusions are discussed in more detail in the following sections. Table S3-1 provides an overall summary of the progress that, based on modeling results for the PIO Guidance Case, would be accomplished for tank waste processsing during Phase 1 and the total mission.

Table S3-1. Mission Progress for Tank Waste Processing.[a]

		Minimum Order Contract Quantities [b]	Completion of Phase 1 [c]	Total Mission (Phase 1 and 2)
In-Situ	Tank WasteVolume (m^3) / % of All Tank Waste	27,250 / 13.6%	59,050 / 29.6%	199,850 / 100%
	Curies [d] / % of All Tank Waste	4.72×10^7 / 20.7%	6.87×10^7 / 30.1%	2.28×10^8 / 100%
LAW	Tank Waste Quantity[e] (dry basis, MT)	16,340	36,380	177,000
	Curies Immobilized [d]	6.45×10^5	1.02×10^6	5.44×10^6
HLW	Tank Waste Quantity[e] (dry basis, MT)	1,040	2,090	23,740
	Curies Immobilized [d]	4.66×10^7	6.76×10^7	2.23×10^8

m^3 = cubic meters
MT = metric tons

[a]Does not include Cs and Sr capsules; Phase 2 processing alternatives are being evaluated by ORP.
[b]LAW Minimum Order quantity is 6,000 units; HLW Minimum Order quantity is 600 canisters.
[c]Based on PIO Guidance Case; includes all wastes staged and processed to fulfill Minimum and Extended Orders.
[d]Radionuclides decayed to 1/1/1994.
[e]As delivered to privatization contractor.

S3.1.1 Phase 1

As discussed in Section S2.3, mission summary diagrams are key results of the HTWOS model and the TFC O&UP evaluations. Figures S3-1 and S3-2 are the Phase 1 mission summary diagrams for the PIO Guidance Case, Minimum Order and Extended Order, respectively. The mission summary diagrams provide information about waste feed source and staging tanks, delivery sequences, schedules, immobilized waste handling, and project interfaces for waste retrieval and disposal. Tables S3-2 and S3-3 provide summaries of waste feed processing estimates for LAW and HLW, respectively, including the Minimum Order and Extended Order quantities of delivered feed and immobilized glass product. Key findings included in these figures and tables are outlined below.

- Vitrification of LAW feed delivered through the last tank in the Minimum Order sequence is projected to be completed by October 2015. A total of 8,509 units of LAW feed is planned for delivery, resulting in a total of 9,830 ILAW packages during the Minimum Order.

- Vitrification of HLW feed delivered through the last tank in the Minimum Order sequence is projected to be completed by May 2017. A total of 13,800 m^3 (3.6 Mgal) of HLW feed will be delivered during the Minimum Order. A total of 965 IHLW canisters will be produced during the Minimum Order, based on Pacific Northwest National Laboratory's glass properties model.

- Extended Order LAW vitrification is projected to be completed by April 2019 if all contingency waste is processed. During the Extended Order, an additional 3,837 units of LAW feed will be delivered, and an additional 4,432 ILAW packages will be produced.

- Extended Order HLW vitrification is projected to be completed by August 2018 if all contingency waste is processed. During the Extended Order, an additional 6,300 m^3 (1.7 Mgal) of HLW feed will be delivered, and an additional 465 IHLW canisters will be produced.

This revision of the TFC O&UP included an assessment of DST space requirements. A key finding of the HTWOS model and the TFC O&UP evaluations is the verification that waste retrieval and staging activities, in conjunction with continuing waste additions from SST salt well pumping and facility generated wastes, can be completed without exceeding available DST space. Figure S3-3 is a plot of the DST volume usage during Phase 1 and shows, among other information, that the available DST space (approximately 121,000 m^3 [32 Mgal]) is sufficient for future waste allocations. Empty DST space is estimated to be not less than about 15,000 m^3 (4 Mgal) and will typically be more. Space usage will be further controlled as Phase 1 proceeds by the rate at which SST waste is retrieved into the DSTs to fill newly available space. Based on these results, new tank construction is not required if the waste transfer and processing schedules modeled for the PIO Guidance Case are maintained.

The results of the HTWOS modeling of immobilized waste production under the PIO Guidance Case are presented in Figures S3-4 and S3-5 for ILAW package and IHLW canister receipt, respectively. The HTWOS projections indicate that ILAW disposal and IHLW storage facilities should be ready in time to begin receiving waste products from BNFL Inc., based on the expectation that in-plant (lag) storage for immobilized product (up to 450 ILAW packages and up to 45 IHLW canisters) will be available at the treatment and immobilization facilities. If constraints are imposed on the available lag storage capacity, and if BNFL Inc. is assumed to process waste at the maximum rates allowed in the ORP and BNFL Inc. contract (ORP 1999), then the HTWOS projects that delivery of ILAW packages and IHLW canisters may begin sooner than previously planned.

The HTWOS model projects that fifty percent of available lag storage capacity could be exceeded for ILAW about four months before the earliest planned date for beginning to receive ILAW packages, and that seventy-two percent of the available capacity could be consumed before delivery to the ILAW disposal facility is planned to begin. The HTWOS model also projects that the fifty percent lag storage capacity could be exceeded for IHLW about five months before the earliest planned date for receiving IHLW canisters, and that ninety-one percent of the available lag storage capacity would be filled before delivery to the IHLW storage facility could begin. As noted, these estimates are based on BNFL Inc. processing waste at the maximum allowed contract rates.

S3.1.2 Balance of Mission

The HTWOS model was used to develop and evaluate difference approaches to accomplishing the Phase 2 (balance of mission) activities, which focus primarily on retrieval and processing of wastes remaining in SSTs. The approaches were based on the following criteria: meeting available ORP direction (key input parameters and ORP direction for Phase 2 were previously discussed in section S2.2); removing waste from those SSTs posing the greatest risk to the public and environment; and, retrieving additional SSTs whenever extra space becomes available in DSTs (referred to as DST backfilling). A scenario was developed that balanced these criteria and integrated Phase 1 and 2 activities.

To facilitate assessment of risk to the public and environment, a simplifying assumption was made that large inventories of ^{99}Tc, high degrees of waste solubility, and indicators of past leakage are all factors that correlate with increased risk. SSTs with high ^{99}Tc inventories and no leak history (the absence of past leakage implies the ability to retrieve with no or minimal loss of waste to the environment) were identified as early candidates for retrieval. Alternatively, SSTs with low ^{99}Tc inventories and known to have leaked large volumes of waste to the soil were identified as candidates for retrieval late in the sequence. Using this approach, ten SST categories were developed. Brief descriptions of these categories, along with a graphic that relates ^{99}Tc retrieval to total SST waste retrieval, are provided in Figure S3-6.

Figure S3-1. Mission Summary Diagram for Case 3S6E - Minimum Order.

Feed Delivery, Storage and Disposal Mission Summary for Case 3S6E R2A

NOTE: See letter 73600-00-001 R.W. Powell for assumptions used in building the mission summary 2006 baseline.
Mission summary for LAW supports a ~2X BNFL ramp-up for vitrification processing.
The mission summary will be evaluated after the BNFL B-1 Contract submittal on 4/24/00.

1. SY-101 waste is being certified as backup to AP-101. If this feed is not used it may require recertificaiton in FY 10 prior to shipment to BNFL.
2. First batch cannot be certified in time to backup batch 10-SY-101. Delay is because staging tank is not available.
3. CHG projection of dates when BNFL Inc. interim storage reached 50% of capacity.

COLOR KEY
- Key Dates (Assumed (A), Derived (D))
- Batch Transfers Complete
- Delivery of Feed Batch to BNFL Feed Tank
- Operational Need Date
- Project Activities, MP=Mixer Pump Installation
- Certification Activities
- Processing Activities
- Staging Activities: Mix or Mobilize (M), Transfer (T), Degas/Transfer (D/T), Dissolve/Mix (D/M)
- SST Sluicing Activities
- Miscellaneous: Backup Feed (B), Flush/Cleanout (F), Mix & Transfer Feed to BNFL (t)
- BNFL/WDOE Certification
- BNFL Pretreatment
- ILAW and IHLW Facility Operation

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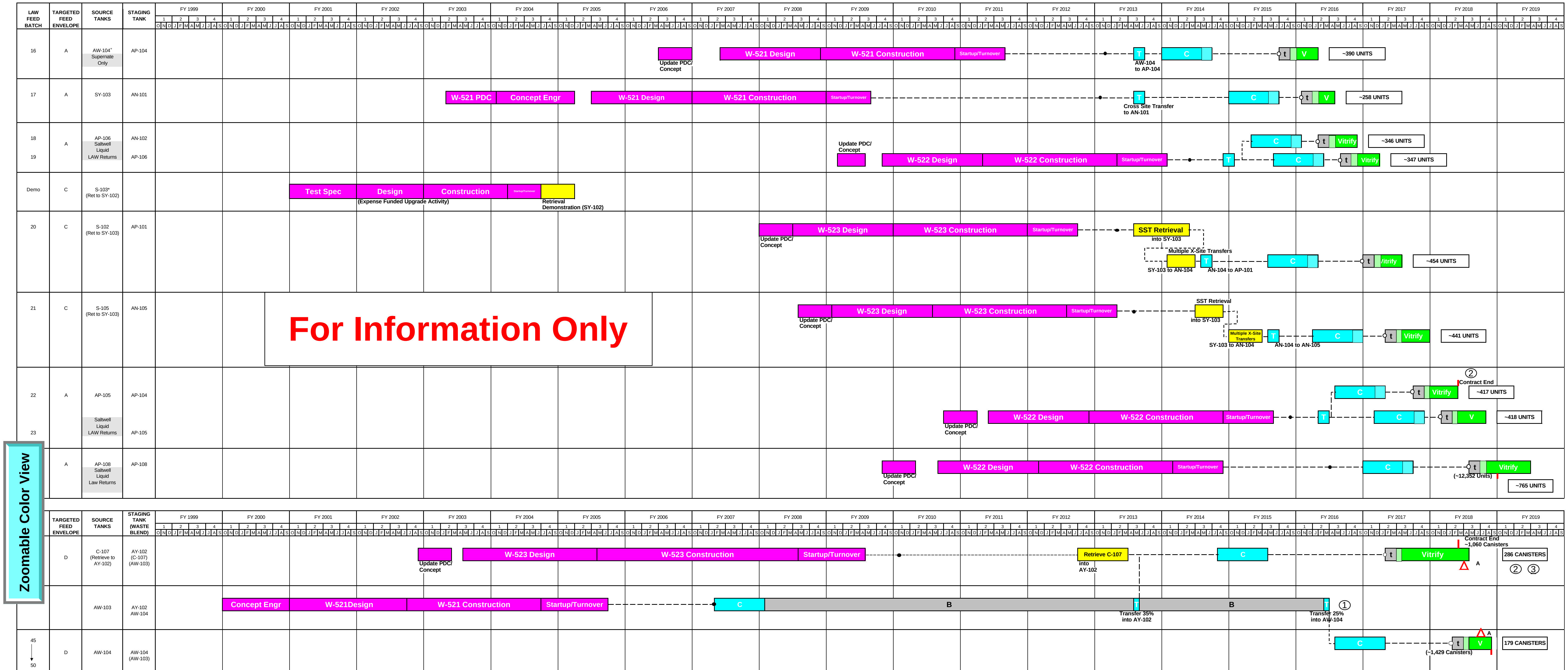
REVISIONS

Figure S3-2. Mission Summary Diagram for Case 3S6E - Extended Order.

Feed Delivery, Storage and Disposal Mission Summary for Case 3S6E R2A, Extended Order



NOTE: See letter 73600-00-001 R.W. Powell for assumptions used in building the mission summary 2006 extended order.
Mission summary for LAW supports a ~2X BNFL ramp-up for vitrification processing .
The mission summary will be evaluated after the BNFL B-1 Contract submittal on 4/24/00.
Mission Summary only addresses WFD transfers. Safe Storage routine waste transfers are not depicted.

1. Percentages of waste from AW-103 transferred AY-102 and AW-104 are to maximize the oxide loading in the blended feed from C-107 and AW-104. 40% remaining will be retrieved in Phase 2

2. Phase 2 processing capacities increase starting March 1, 2018. Derived from BNFL Inc. contract end date of February 28, 2018.

3. Vitrification end dates are based on a Phase 2 HLW capacity of 14 MT IHLW per day (60%TOE) because of insufficient time to add a second HLW plant to the HTWOS model.

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Table S3-2. Summary of Low-Activity Waste Feed Processing.

Envelope [a]	Feed source	Staging tank	Batch	Delivered LAW Feed: Units of LAW feed planned	Delivered LAW Feed: Sodium delivered (MT)	Delivered LAW Feed: Radioactivity [b] (Ci)	ILAW Glass Production: Mass of ILAW glass (MT)	ILAW Glass Production: Volume of ILAW glass [c] (m^3)	ILAW Glass Production: Number of ILAW packages [d]
Privatization Phase 1 Minimum Order									
A	AP-101	none	1	615	615	1.88E+04	4,272	1,606	711
B	AZ-101 AZ-102	none none	2a 2b	1,308	503	3.92E+04	9,080	3,414	1,511
C	AN-102	none none	3 4	556 556	484 484	9.30E+04 9.27E+04	3,862 3,861	1,452 1,451	643 642
A	AN-104	none AN-101	5 6	439 406	439 406	7.35E+03 6.78E+03	3,045 2,819	1,145 1,060	507 469
C	AN-107	none	7	808	703	1.38E+05	5,610	2,109	934
A	AN-105	AN-102 none	8 9	425 414	425 414	2.20E+04 1.61E+04	2,948 2,872	1,108 1,080	491 478
A	SY-101 [e]	AP-104 AN-101	10 11	298 529	298 529	1.64E+04 2.34E+04	2,070 3,672	778 1,380	344 611
A	AN-103	AN-102 none	12 13	542 542	542 542	1.03E+04 9.80E+03	3,760 3,765	1,414 1,416	626 627
A	AW-101	AN-105 none	14 15	453 617	453 617	1.51E+04 1.94E+04	3,146 4,283	1,183 1,610	523 713
Privatization Phase 1 Minimum Order (6,000 Units of LAW)				8,509	7,453				9,830
Privatization Phase 1 Extended Order									
A	AW-104 (saltwell liquor)	AP-104	16	390	390	1.18E+04	2,707	1,018	451
A	SY-103	AN-101	17	258	258	8.07E+03	1,791	673	298
A	AP-106 (saltwell liquor)	AN-102 none	18 19	346 347	346 347	1.60E+04 1.65E+04	2.405 2.406	904 904	400 400
C	S-102 (S-103, S-105)	AP-101	20	454	395	5.49E+04	3,152	1,185	525
C	S-105 (S-106, S-108)	AN-105	21	441	384	5.31E+04	3,062	1,151	510
A	AP-105	AP-104 none	22 23	417 418	417 418	1.38E+04 1.37E+04	2.897 2,901	1.089 1,091	482 483
A	AP-108 (saltwell liquor)	none	24	765	765	5.06E+04	5,311	1,997	884
Privatization Phase 1 Extended Order				3,837	3,720				4,432
Privatization Phase 1 Total				12,346	11,173				14,262

Values should be treated as estimates, due to uncertainties of input data (e.g., inventory), numerical rounding, and limitations of model assumptions and calculations.

Ci = Curies

ILAW = Immobilized low-activity waste

LAW = Low-activity waste

m^3 = Cubic meters

MT = Metric tons

none = The feed source tank performs the staging tank functions for the corresponding batch; feed will be delivered directly from the source tank to BNFL Inc.

[a]Assumed envelope is based on current contract specifications (ORP 1999) and currently available characterization data

[b]Decayed to calendar year of start of delivery

[c]glass density = 2.66 MT/m^3

[d]2.23 m^3 of ILAW glass per package

[e]The Minimum Order quantity is met midway through Batch 11.

Table S3-3. Summary of High-Level Waste Feed Processing.

Batch group	Batches	Feed source	Staging tank	Planned HLW Feed				IHLW Glass Production[d]				
				Liquids (ML)	Solids[a] (MT)	Volume[b] (ML)	Radioactivity[c] (Ci)	Non-volatile waste oxides[e] (MT)	Waste oxide loading[f] (%)	Mass of IHLW glass (MT)	Volume of IHLW glass[g] (m^3)	Number of IHLW canisters[h]
Privatization Phase 1 Minimum Order												
1	1-6	AZ-101	AZ-101	3.02	102	3.05	9.42E+06	84	30.6%	249	93	81
2	7-12	AZ-102	AZ-102	3.17	171	3.23	5.01E+06	134	30.9%	375	141	123
3	13-19	AY-102/C-106	AY-102	1.95	381	2.08	3.82E+06	192	29.0%	584	219	191
4[i]	20-31	AY-101/C-104	AY-101	3.15	643	3.37	2.00E+06	359	32.4%	1,049	394	343
5	32-35	SY-102	AZ-101	2.02	168	2.08	6.79E+05	133	6.1%	696	262	227
Privatization Phase 1 Minimum Order (600 canisters of IHLW)												965
Privatization Phase 1 Extended Order												
6	36-44	C-107/AW-103 (35%)	AY-102	3.04	474	3.20	1.19E+06	287	29.3%	875	329	286
7	45-50	AW-104/AW-103 (25%)	AW-104	3.01	150	3.06	3.57E+05	150	25.7%	548	206	179
Privatization Phase 1 Extended Order												465
Privatization Phase 1 Total												1,430

Values should be treated as estimates, due to uncertainties of input data (e.g., inventory), numerical rounding, and limitations of model assumptions and calculations.

Ci = Curies
m^3 = Cubic meters
ML = Million liters
MT = Metric tons

[a] Total solids for batch group assuming expected retrieval efficiencies.
[b] Batch volumes delivered are 0.2 to 0.6 ML each including inhibited flush water.
[c] Based on delivered feed, including both solids and liquids, decayed to calendar year of start of delivery.
[d] Glass production based on the Pacific Northwest National Laboratory's glass properties model. This model provides a conservative basis for planning the quantity of HLW feed required to meet BNFL Inc. production needs.
[e] Not including glass frit, but including waste Na_2O and SiO_2.
[f] Not including waste Na_2O and SiO_2 contained in the waste feed.
[g] Glass density = 2.66 MT/m^3.
[h] 1.15 m^3 of IHLW glass per canister. Number of canisters assumes expected retrieval efficiencies of sludge from source tanks. Due to rounding, the sum of canisters may not equal the total (cumulative).
[i] The Minimum Order quantity is met about halfway through Batch Group 4.

Figure S3-3. Total Phase 1 Double-Shell Tank Volume Usage Plot.

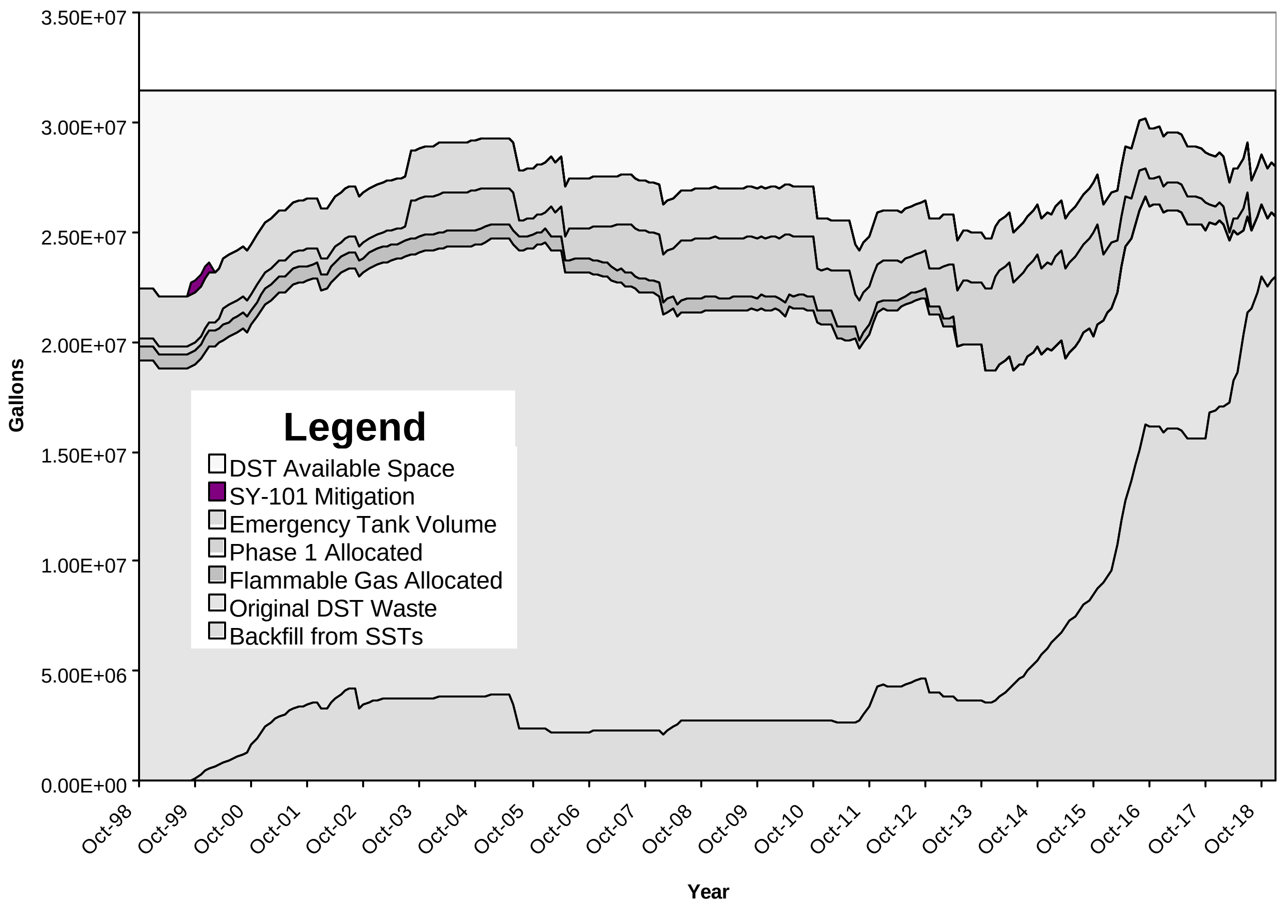


Figure S3-4. Immobilized Low-Activity Waste Package Receipt Schedule.

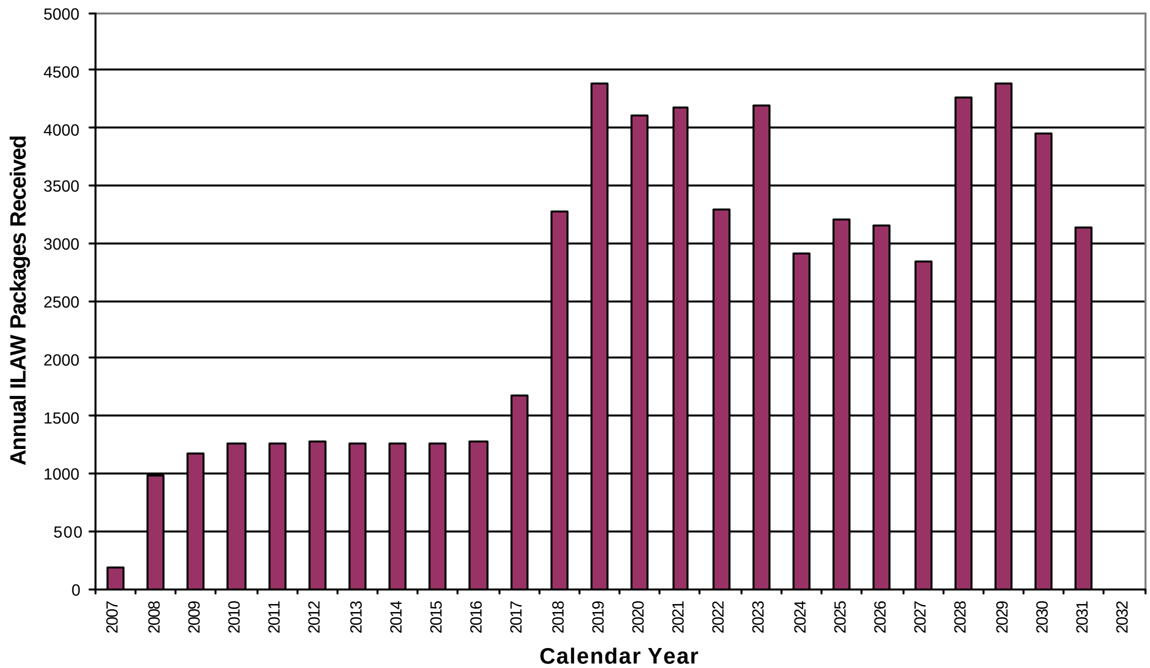


Figure S3-5. Immobilized High-Level Waste Canister Receipt Schedule.

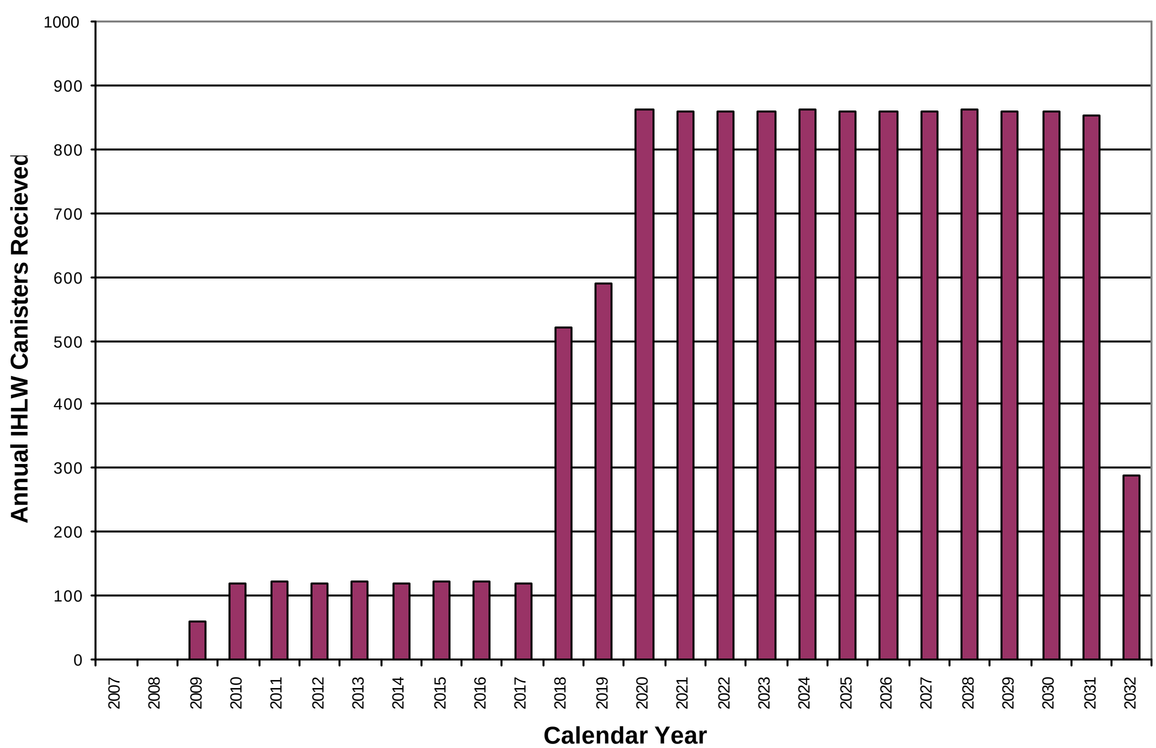
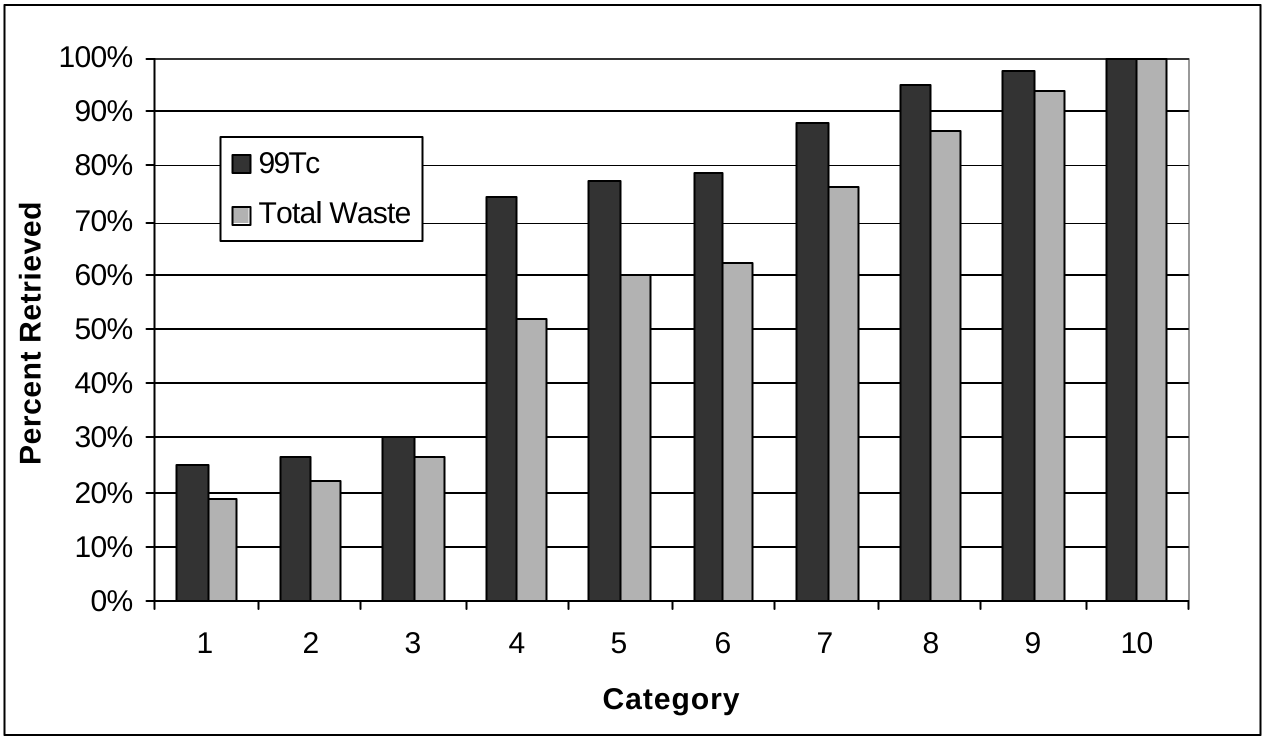


Figure S3-6. Cumulative Percent of Total Tank Waste and ^{99}Tc Retrieved from Single-Shell Tanks.*



<u>Categories</u>:

Category 1 - Sound salt cake tanks with high levels of ^{99}Tc

Category 2 - Sound sludge tanks with less than 1.8 m (6 ft) of sludge

Category 3 - Sound salt cake tanks with lower levels of ^{99}Tc.

Category 4 - Sound salt cake/sludge mixed tanks with less than 1.8 m (6 ft) of sludge

Category 5 - Sound sludge tanks with more than 1.8 m (6 ft) of sludge

Category 6 - Sound salt cake/sludge mixed tanks

Category 7 - Leaking salt cake tanks

Category 8 - Leaking salt cake/sludge mixed tanks

Category 9 - Leaking sludge tanks with less than 1.8 m (6 ft) of sludge

Category 10 - Leaking sludge tanks with more than 1.8 m (6 ft) of sludge

*Cumulative percent retrieved assumes each SST category is retrieved in progression from 1 to 10. For example, retrieving categories 1, 2, 3, and 4 SSTs, would result in approximately 75 percent of the ^{99}Tc being retrieved.

After satisfying ORP direction and accounting for risk reduction objectives, DSTs were assumed to be backfilled with SST waste as soon as DST space was made available by waste feed transfers to the treatment and immobilization facility. DST backfilling is important for maintaining steady availability of waste feed and orderly delivery, so that tank farm and waste processing facilities are not unnecessarily idle. To best meet the DST backfilling objective, consideration was given to the number of receiver tanks for staging retrieved waste; composition of the retrieved waste; importance of blending to reduce impacts of problem waste constituents; efficient usage of available retrieval equipment; desire to minimize the number of new systems and simultaneous retrievals; and, need to match feed specification to operational requirements of the waste processing facilities.

The TFC O&UP provides additional details on the SST retrieval sequence and the rationale for selecting this sequence. Alternative cases will continue to be run using the HTWOS model to further develop the Phase 2 waste retrieval and processing strategy. Key balance of mission findings include the following.

- Retrieval rates are not expected to be a constraining factor on the ability to deliver waste feed during Phase 2, assuming that facility equipment and upgrades are installed on time.

- SST waste retrieval will be completed by 2028 and waste processing will be completed by 2032, based on the identified SST retrieval sequence and ORP-directed processing rates.

- DST storage capacity is adequate to support Phase 2 needs, and is not a constraining factor relative to immobilization plant capacity and SST retrieval rates. This enables the use of available DST capacity for increased blending of waste from individual SSTs to achieve more optimal waste feeds.

- A total of about 49,800 packages of ILAW (average rate of about 3,890 packages per year) and a total of about 11,300 canisters of IHLW (average rate of about 830 canisters per year) will be produced during Phase 2, based on Phase 1 waste loading rates and container dimensions. The substantially increased production rates provided in the ORP direction will require correspondingly higher rates of transportation, packaging, receipt, storage, and disposal.

S3.2 ALTERNATIVE CASES – ANALYZING SENSITIVITY TO CHANGES

The sensitivity of current planning to changes in technical direction was assessed by running the HTWOS model with variations of the input parameters, then comparing the results of these alternative cases. Some of the variations included earlier processing start dates, faster processing rates, and changes in the effectiveness with which waste constituents are concentrated in the immobilized glass product (waste loading). Major findings from these sensitivity analyses are summarized below.

S3.2.1 Summary of Alternative Cases

The speed and flexibility of the HTWOS makes it possible to model a large number of alternative cases. More than a dozen alternatives have been modeled using the HTWOS for this revision of the TFC O&UP; they are summarized below as variations of three general scenarios:

- Changes in start-up schedules for the treatment and immobilization facilities. Start-up may be sooner or later than planned. Earlier start-up dates are often associated with a percent likelihood of success at achieving that earlier date (e.g., 50 percent chance of starting one year earlier).

- Changes in the rate at which the treatment and immobilization facilities are able to achieve their maximum sustainable operating rate. It is expected that a new facility can not immediately begin operating at maximum production efficiency, so common engineering practice is to assume ramp-up rates for a period of time after start-up.

- Changes in waste loading in the immobilized glass product. Higher loading factors reflect greater processing efficiencies and are generally desirable, but increasing the loading can have adverse effects on constituent leachability, glass durability, surface radiation levels, heat generation, secondary waste generation, and other factors.

The TFC O&UP details the alternative cases, input parameters, and associated results.

S3.2.2 Sensitivity Analyses

Low-Activity Waste Processing

The alternative cases that were evaluated found that LAW processing is not significantly impacted by a reasonable range of changes and variations. The alternatives did reveal a few variables that could have moderate impacts on LAW feed delivery scheduling and on ILAW package production. The significant variables and associated impacts are as follows:

- Accelerating the start of LAW processing by up to one year would require that LAW feed delivery be accelerated by 11 months. This earlier delivery could be addressed by a combination of reduced float in the delivery schedule, and moving up the completion dates for some of the planned facility projects and upgrades. No change in the quantity of ILAW package production is expected.

- Removal of sulfates from the LAW feed has the benefit of improving glass waste loading efficiencies. However, sulfate removal is a potentially burdensome technology that may have other unacceptable disadvantages. Relative to the PIO Guidance Case, sulfate removal could result in decreasing ILAW production by up to 873 packages. No changes in completion dates would occur, assuming that the decreased ramp-up rate modeled for this sensitivity analysis is maintained.

- Sodium washing will be used to reduce the amount of IHLW produced and the number of IHLW canisters to be stored and eventually disposed. Sodium washing generates a secondary waste stream that will be returned to the LAW processing system of the vitrification plant. The effect of this additional treatment would be to extend processing completion by up to nine months, and increase ILAW production by up to 915 packages.

High-Level Waste Processing

The alternative cases revealed several variables that can have significant impacts on HLW feed delivery and IHLW production. Most of the variables are related to how effectively waste constituents can be loaded into the final glass product. Waste loading factors considered in the sensitivity analyses included increased waste oxide loading in the IHLW; blending of LAW precipitates (e.g., manganese and strontium from Envelope C pretreatment); presence of entrained solids; and, effects of blending different tank wastes. Factors related to processing ramp-up rates and early start of HLW vitrification were also important to the sensitivity analyses.

The overall conclusion of the HLW sensitivity analyses is that, for reasonably likely alternative scenarios, HLW feed delivery and IHLW storage can be accomplished within the existing tank farm system. However, some scenarios indicate potentially adverse impacts on the ability to deliver HLW feed in accordance with desired schedules. The sensitivity analyses resulted in the following key findings:

- Increasing loading factors for waste constituents in the immobilized glass product would require an increase in the rate at which HLW feed is delivered. Significant loading increases could surpass the ability of the HLW feed infrastructure to support delivery demands, possibly requiring acceleration of current projects and additional new equipment and upgrades.

- Substantial increases in waste loadings (e.g., to levels proposed by BNFL Inc.) could decrease the total amount of IHLW produced by up to 260 canisters. The net effect would be a reduction in the overall storage capacity required for IHLW. In the absence of other constraints (e.g., assuming sustainable waste feed delivery rates), HLW feed processing could be completed as much as 26 months sooner.

- The Pacific Northwest National Laboratory's glass properties model provides waste loading efficiencies that are higher than the ORP and BNFL Inc. contract (ORP 1999) currently requires. Using the contract specification requirements results in increased quantities of IHLW produced, which provides a more conservative planning basis for IHLW canister receipt and storage. During Minimum Order, up to 1,094 IHLW canisters could be produced (about 130 more canisters than calculated using the glass properties model), and up to 494 IHLW canisters could be produced during Extended Order (about 30 more canisters than calculated using the glass properties model).

- Earlier start-up accelerates HLW feed delivery dates and IHLW return dates by up to 16 months. Decreasing planned feed delivery processing ramp-up rates to match the

BNFL Inc. ramp-up rates has the opposite effect, extending completion by up to nine months. Neither scenario affects the total quantity of IHLW that is produced.

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GLOSSARY OF TERMS AND ACRONYMS

COMMON TERMS AND DEFINITIONS

Backup Waste. Backup waste includes all LAW and HLW feed certified by both CHG and BNFL Inc. as acceptable for delivery to BNFL Inc. at any time as distinguished from the LAW and HLW feeds that are planned for delivery in the current sequence. Backup waste will be delivered to BNFL Inc. only when a problem occurs that prevents delivery of the waste feed in the planned sequence. Backup waste includes the next tank of waste in the delivery sequence (if it is certified) and a small number of tanks of waste certified well in advance of the delivery need dates.

Batch. The quantity of waste feed of a given type, and its associated flush and dilution water, requested by BNFL Inc. for transfer to its receiving tank at one time. Flush and dilution water sent to BNFL Inc. is added to the definition, because it will be part of the fluid received by BNFL Inc.

Best-Basis Inventory. A database of peer reviewed, accepted, and controlled information providing total tank and tank-specific estimates for chemical and radionuclide components, and selected waste parameters and characteristics in the 177 Hanford Site SSTs and DSTs.

Canister. A canister of immobilized HLW comprises a 4.5-m high, 0.61-m diameter metal container holding, on average, 3.1 MT of waste glass at a density of 2.66 MT/m^3.

Capillary Height. The maximum height to which an unsaturated layer of waste particles will draw liquid upward between the particles (i.e., through the capillaries). The finer the particles, the greater the capillary height.

Contingency Waste. Contingency wastes are the wastes planned for delivery after the minimum quantities needed to support the Minimum Order (i.e., 6000 units of LAW and 600 canisters of HLW) and Extended Order are delivered. The availability of contingency waste allows risks associated with inadequate waste feed delivery to be mitigated, including failure of a tank of waste feed to satisfy BNFL Inc. waste acceptance criteria, inadequate waste retrieval efficiency, and failure in the physical system, such as developing a leak in a tank or pipeline.

Envelope or **Waste Feed Envelope**. An approach to defining predetermined and agreed-upon chemical and radionuclide limits in the waste feed. The approach provides increased assurances about the range of waste compositions that the privatization contractor will be required to treat and immobilize, allows demonstration of different waste processing capabilities of the contractor's facilities, and enhances flexibility in deciding how to deliver waste. Three envelopes have been specified for LAW feed (Envelopes A, B, and C) and one envelope for HLW feed (Envelope D). Current specifications for each envelope are defined in the contract between ORP and BNFL Inc (ORP 1999).

Flowsheet or **Mass-Balance Flowsheet**. A flowsheet is an engineering document that describes each input and output process flow to the unit operations that make up an overall chemical process. Ion exchange and waste pumping are examples of unit operations. The total mass of all components in the input streams must equal the total mass of all components in the output streams and include the residual components in a completed flowsheet. Hence, the mass is balanced across each unit operation and the total system. Similarly, the total energy input must equal the total energy output plus the net change in residual energy of the overall chemical process.

Heel or **Tank Waste Heel**. A heel or tank waste heel is the residual waste that remains in a tank following waste retrieval and/or waste feed delivery to BNFL Inc.

Interim Stabilization. The process of stabilizing SSTs to reduce leakage potential, using actions such as pumping interstitial liquids from SST wastes, stopping water additions, and minimizing other potential liquid inflows.

Interstitial Liquid. Interstitial liquid is the liquid fraction contained in the spaces (interstices) between individual solid particles in waste sludge.

Leach Factor. A leach factor is the fraction of a waste constituent removed (leached) from HLW sludge by mixing the sludge with a caustic solution (typically about 3 molar sodium hydroxide).

Mixer Pump. A modified centrifugal pump that draws in liquid waste and ejects the waste from two opposing ports in the impeller housing near the tank bottom at high rates. The tank contents are mixed as a consequence of the high rate of waste injection and changing the orientation of the ports.

Out-of-Specification Waste. Out-of-specification waste is LAW or HLW feed that does not meet the specifications contained in the ORP and BNFL Inc. contract (ORP 1999). The BNFL Inc. waste acceptance criteria for LAW and HLW feeds may be less constraining than the contract specifications.

Package. A package of immobilized LAW comprises a 2.3-m high, 1.22-m diameter metal container holding, on average, 6.0 MT of waste glass at a density of 2.66 MT/m^3.

Partitioning. When water is combined with a solid (e.g., salt cake, waste sludge), a fraction of the solid dissolves in accordance with the specific solubility of each chemical in the solid. Partitioning refers to the fraction of each chemical that dissolves in the water and the fraction that remains with the solid.

Sluicer and **Sluicing**. Sluicing is a method of mobilizing settled tank waste, usually to facilitate retrieval of the waste solids. The method employs a nozzle that directs a stream of liquids at the settled solids, thereby dislodging, dissolving, and suspending them in a liquid slurry, and pumping the slurry from the tank. A sluicer is the device that performs the waste sluicing.

Slurry. A mixture of waste liquids and suspended sludge particles.

Source Tank. A source tank is a SST or DST that contains a source of waste feed. A source tank usually requires retrieval actions (e.g., sluicing, mixing, dilution, dissolution, pumping) to prepare and stage the waste for delivery to BNFL Inc. Waste qualification samples are taken from source tanks and analyzed to establish the preliminary acceptability of the waste for delivery to BNFL Inc. Certain DST source tanks may also serve as staging tanks if all or some fraction of the wastes contained in the tank can be certified as meeting the ORP and BNFL Inc. contract (ORP 1999) specifications, as applicable, and the CHG pumpability criteria.

Staging Tank. A staging tank is a DST that is used for preparing and containing waste feed prior to delivery. A staging tank usually is equipped with a mixing pump(s) to homogenize the waste prior to sampling and/or pumping to BNFL Inc. Waste certification samples are taken from staging tanks and analyzed to establish final acceptability of the waste feed for delivery to BNFL Inc.

Unit. The term “unit” reflects the difficulty of processing LAW feed. One metric ton of elemental sodium contained in LAW Envelopes A, B, and C waste feed is equivalent to 1.0, 2.6, and 1.15 units, respectively, as stated in the ORP and BNFL Inc. contract (ORP 1999).

Wash Factor. A wash factor is the fraction of a waste constituent removed from HLW sludge by actively washing the sludge with water or very dilute caustic solution (typically less than 0.1*M* sodium hydroxide).

Waste Certification. CHG waste certification is conducted using split, composited samples of staged waste feed to verify compliance with the ORP and BNFL Inc. contract (ORP 1999) specifications, as applicable. Waste certification activities are also conducted by BNFL Inc. on the other split, composited samples to verify compliance with environmental permit conditions and authorization basis limits.

Waste Feed Delivery System. The combination of the existing physical system and the future physical system that will be put in place to support tank waste retrieval and delivery to the treatment and immobilization facility.

Waste Feed Qualification. CHG waste feed qualification is conducted using samples of tank waste to qualify the tanks as candidate sources of waste feed. Qualification activities include waste sampling and laboratory analysis of the waste samples to the designated envelope specifications defined in the ORP and BNFL Inc. contract (ORP 1999) specifications. Qualification also includes laboratory testing of physical and chemical characteristics of the waste (e.g., rheology, settling rates, ease of dissolution) to establish preliminary design and operating parameters for retrieving and pumping the waste to BNFL Inc. Waste feed qualification activities are performed before the waste is certified to avoid the high cost of installing waste retrieval systems in tanks that are unsuited for waste retrieval and delivery of waste feed that may not be acceptable to BNFL Inc. Waste feed qualification should not be confused with the “waste qualification” process used by the Nuclear Regulatory Commission to determine if the waste is acceptable for emplacement in the Federal HLW respository.

Waste Transfer Day. The waste transfer day is the earliest day that BNFL Inc. will accept the transfer of a given batch of waste feed into its receiving tank. It is requested in writing and formally agreed to in accordance with the appropriate interface control documents.

LIST OF ACRONYMS

CHG	CH2MHILL Hanford Group, Inc.
DOE	U.S. Department of Energy
DST	Double-shell tank
HLW	High-level waste
HTWOS	Hanford Tank Waste Operation Simulator
IHLW	Immobilized high-level waste
ILAW	Immobilized low-activity waste
LAW	Low-activity waste
ORP	Office of River Protection
PIO	Project Integration Office
RPP	River Protection Project
SST	Single-shell tank
TFC	Tank Farm Contractor
TFC O&UP	Tank Farm Contractor Operation and Utilization Plan
TWINS	Tank Waste Information Network System
wt%	percent by weight

ATTACHMENT 1

THE TANK FARM CONTRACTOR OPERATION AND UTILIZATION PLAN, VOLUMES I AND II – ORGANIZATION AND CONTENT

ATTACHMENT 1

THE TANK FARM CONTRACTOR OPERATION AND UTILIZATION PLAN, VOLUMES I AND II – ORGANIZATION AND CONTENT

This appendix provides section by section summaries of the contents of Volumes I and II of the *Tank Farm Contractor Operation and Utilization Plan* (TFC O&UP). The summaries describe the purpose and intent of each section, with relevance to the overall objectives of the TFC O&UP. This roadmap enables a reader who first encounters the TFC O&UP to generally know where the methods, calculations, simulations, results, findings, and supporting information can be found in the document.

TFC O&UP – Volume I

1.0 INTRODUCTION TO THE OPERATING PLAN

This section briefly summarizes the different versions of events and tank waste processing scenarios (referred to as "cases") that have been evaluated in the current revision of the TFC O&UP. This section provides information on how different cases were evaluated and how the results contribute to technical baseline and multi-year work planning activities. Finally, this section introduces key elements used to define and distinguish the different scenarios that have been evaluated.

2.0 AN OVERVIEW OF HANFORD TANK WASTE OPERATION SIMULATOR

The Hanford Tank Waste Operation Simulator (HTWOS) is the primary computer simulation model used to develop and evaluate different cases. This section provides a general overview of how information is used by the HTWOS model to obtain the results presented in the TFC O&UP. Specific subsections are devoted to discussions of the following:

- Sources of information (e.g., contractual requirements, interface control documents) and their roles in assembling the constraints, requirements, and assumptions used to develop different cases for HTWOS evaluation.
- The Best-Basis Inventory, as the primary source of waste quantity, chemical, and radionuclide data used in the HTWOS model.
- Methods and limitations of the calculations used to determine the inventories of different waste feeds at the point of delivery.
- Generic bases and rationale for source tank selection.
- Approaches to staging low-activity waste feed prior to delivery and the influences affecting the choice of staging tanks.

- Assumptions and methods used to model the processing and incorporation of constituents into the final glass products.

- The criteria and logic for selecting retrieval sequences for single-shell tanks (SSTs).

Other general assumptions and constraints (e.g., minimum periods for waste degassing, time to complete laboratory analyses) that affect tank sequences and the waste feed delivery schedule are described throughout this section.

3.0 LOW-ACTIVITY WASTE FEED STAGING FOR CASE 3S6E

In this revision of the TFC O&UP, Case 3S6E, which is based on current (through March 2000) Project Integration Office (PIO) guidance (PIO 2000), represents the principal scenario for retrieving, staging, and delivering waste feed to BNFL Inc. This section of the TFC O&UP describes the results of Case 3S6E, and of different alternate cases, for low-activity waste processing. Information provided in this section includes the following:

- The waste source tanks, staging tanks, order and timing of retrieval.

- Projected quantities and characteristics of low-activity waste product.

- Estimates of how closely the low-activity waste feed will comply with Office of River Protection (ORP) and BNFL Inc. contract (ORP 1999) specifications.

- Identification of equipment needs and other capabilities required to support the selected retrieval and delivery scenario.

- Schedules for performing waste feed delivery, for required construction and upgrades to the tanks and delivery systems, and for coordinating with other operations and tank usage.

- Need for and relationship of the selected retrieval and delivery scenario to development of detailed, tank-specific flowsheets for each waste feed batch or sequence.

- Sensitivity analyses of the above results for alternative cases with different constraints and planning assumptions.

4.0 PHASE 1 HIGH-LEVEL WASTE FEED STAGING

This section of the TFC O&UP describes for high-level waste processing essentially the same types of results and findings provided in Section 3.0 for low-activity waste (e.g., tank sequencing, composition estimates, equipment needs, related schedules, sensitivity analyses).

5.0 PHASE 2 FEED STAGING

The majority of waste sources during Phase 2 will be SSTs that will be transferred to treatment and immobilization facilities via double-shell tanks (DSTs). This section of the TFC O&UP develops a plausible scenario for retrieving, staging, and delivering waste feed during Phase 2, and generally assesses the ability of this scenario to support River Protection Project (RPP) mission objectives. The scenario is further developed with waste feed staging sequence and schedule strategies. Sluicing is the baseline retrieval technology assumed for SSTs (alternative SST retrieval technologies are being evaluated, and may be implemented depending on risk reduction, efficiency, cost, and other considerations). Equipment needs are developed in this section of the TFC O&UP to support sluicing retrieval. This section concludes with discussions of the key factors (e.g., glass formulation, physical systems, immobilization facility processing capacity) that contribute to sensitivities in the Phase 2 waste feed delivery analyses.

6.0 PRODUCT RECEIPT, STORAGE, AND DISPOSAL

This section of the TFC O&UP discusses how immobilized product from treatment and vitrification processes will be received and managed. The general management approach will be to dispose of immobilized low-activity waste product in a near-surface disposal site located on the Hanford Site, and to temporarily store immobilized high-level waste product at the Hanford Site until it can be accepted for final disposal at the national high-level waste repository being developed in Nevada. This section addresses key aspects of this management approach, relative to the Case 3S6E waste processing scenario. Information provided in this section includes the following:

- Impacts on the planned immobilized low-activity waste product disposal facility design, construction, and operation.
- Impacts on designing, constructing, and operating the immobilized high-level waste product storage facility.
- Issues regarding facility designs, construction schedules, and operation and maintenance plans in order to support the Case 3S6E waste processing scenario.
- Sensitivity analyses of the above results for alternative cases with different constraints and planning assumptions.

7.0 DOUBLE-SHELL TANK SPACE MANAGEMENT

This section of the TFC O&UP discusses how the Case 3S6E waste processing scenario may affect management of the storage capacity in the DSTs. Two broad uses for the available capacity need to be considered: receipt and storage of wastes generated during ongoing RPP operations and Hanford Site cleanup activities; and, receipt and storage of wastes retrieved from SSTs. Retrieval of SST waste is a stakeholder priority, due to the deteriorating condition of and past leaks from SSTs. In addition, having wastes staged and ready for future processing will be important for schedule and cost efficiencies as the Phase 2 waste treatment and disposal strategy evolves. Consequently, even though treatment of most SST wastes won't occur until Phase 2 processing, early transfer of SST wastes into the DSTs is a desirable objective. One key result of the Case 3S6E evaluation is a projection of volumes and schedules for tank space availability in the DSTs. After accounting for additions from ongoing work, the residual DST capacity can be used to receive retrieved SST wastes. This section concludes with recommendations on backfilling available DST capacity, as it becomes available, with SST wastes.

8.0 REFERENCES

Self-explanatory.

TFC O&UP – Volume 2 (Appendices)

APPENDIX A – BASES AND ASSUMPTIONS

As would be expected with any evolving system, there are numerous uncertainties which, depending on how they are resolved, could have significant impacts on how tank wastes will be treated and disposed. For example, analytical data are not complete, so the ability of some tanks to provide waste that meets envelope specifications must be assumed for certain constituents. Pending final resolution of such uncertainties, planning for waste retrieval and disposal must proceed by making reasonable assumptions, deriving secondary requirements, or imposing unilateral constraints for the physical systems and processes that are being modeled and evaluated. This appendix of the TFC O&UP documents the derived requirements, enabling assumptions, and other internal constraints that affect the processing scenarios and simulation models. This appendix also describes the guidance and assumptions used to develop the engineering calculations and computer simulations (e.g., HTWOS). Discussions of important issues, degree of uncertainty, and severity of potential impacts are also included.

APPENDIX B – INVENTORY

Appendix B documents the inventory basis used by the TFC O&UP models and simulations to estimate DST waste ("as is") compositions, project waste feed ("as delivered") compositions, and perform other inventory-dependent calculations. This inventory basis is developed using the information and data in the Hanford Best-Basis Inventory. Appendix B includes extensive spreadsheets that provide tank-by-tank inventory data, wash and leach factors, and other significant parameters of interest for chemical and radionuclide constituents in each tank's waste.

APPENDIX C – CHARACTERIZATION DATA NEEDS

Developing and evaluating different waste processing scenarios, such as Case 3S6E, helps to highlight key areas where additional characterization data are required. These characterization data may be needed for various reasons, such as the following:

- Confirming that the waste in selected source tanks will meet contractual requirements

- Refining inventory information needed for mass balance calculations and process flowsheets

- Determining chemical or physical properties of tank waste that are important to design or operate retrieval, delivery, treatment, storage and disposal processes

- Identifying constituents and concentrations needed for environmental, safety, or other permitting and licensing needs.

This appendix describes additional tank waste and other characterization data needs.

APPENDIX D – HIGH-LEVEL WASTE SUPPORTING DOCUMENTATION

This appendix provides an engineering record that supports traceability, reproducibility, and reliability of the work associated with evaluating different high-level waste feed alternatives. Materials provided in this appendix include inventory data, delivered waste batch composition tables, glass composition tables, and other supporting documentation for high-level waste (summarized in Sections 4.0 and 5.0 of the TFC O&UP).

APPENDIX E – LOW-ACTIVITY WASTE SUPPORTING DOCUMENTATION

This appendix provides an engineering record that supports traceability, reproducibility, and reliability of the work associated with evaluating different low-activity waste feed alternatives. Materials provided in this appendix include inventory data, waste batch delivery tables, waste envelope specification compliance tables, modeling results, calculations, and other documentation used to identify source tanks and retrieval and delivery sequences for low-activity waste (summarized in Sections 3.0 and 5.0 of the TFC O&UP).

APPENDIX F – SINGLE-SHELL TANK RETRIEVAL SUPPORTING DOCUMENTATION

This appendix provides an engineering record that supports traceability, reproducibility, and reliability of the work associated with evaluating different SST retrieval alternatives. Materials provided in this appendix include source data, tables, figures, analyses, calculations, simulation and modeling results, and other documentation used to develop a recommended SST retrieval sequence and DST backfilling strategy (summarized in Section 7.0 of the TFC O&UP).

APPENDIX G – STORAGE AND DISPOSAL SUPPORTING DOCUMENTATION

This appendix provides an engineering record that supports traceability, reproducibility, and reliability of the work associated with evaluating immobilized waste product storage and disposal requirements. Materials provided in this appendix include inventory tables for immobilized low-activity and high-level waste products, delivery schedules, capacity modeling, calculations, and other documentation used to develop and evaluate facilities for receiving and managing immobilized waste product (summarized in Section 6.0 of the TFC O&UP).

APPENDIX H – CASE 3S6E SUPPLEMENTAL INFORMATION

This appendix provides a place for collecting a variety of other types of information developed by or in support of TFC O&UP, primarily to assist technical operations and management decision makers. Materials assembled in Appendix H include summary-level graphics prepared to support RPP mission analyses; plots of DST volumes and usage; detailed tables projecting waste transfers during Phase 1; mass balance sheets for modeling process flows, constituent and materials movements, and blended waste compositions; and, figures depicting physical systems and configurations for tank waste retrieval, staging, and delivery.

APPENDIX I – PROCESS TECHNICAL BASIS

This appendix collects relevant background information (not already included in Appendix A) used to establish the technical basis for the tank waste retrieval and disposal process. Information provided in Appendix I includes, but is not limited to: a master set of components to be used by the TFC O&UP models and simulations; methods for calculating various waste physical properties (e.g., density, viscosity); relevant information on phase equilibrium phenomena that occur in Hanford Site tank wastes; current knowledge base for solubility and caustic leaching of constituents in solids; and, methodology for determining waste oxide loading in the immobilized waste glass products.

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ATTACHMENT 2

SAMPLE CALCULATIONS--ESTABLISHING THE RELIABILITY OF RESULTS IN THE TANK FARM CONTRACTOR OPERATION AND UTILIZATION PLAN

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ATTACHMENT 2

SAMPLE CALCULATIONS--ESTABLISHING THE RELIABILITY OF RESULTS IN THE TANK FARM CONTRACTOR OPERATION AND UTILIZATION PLAN

Section S2.0 of this summary document describes how the Hanford Tank Waste Operation Simulator (HTWOS) models tank waste processing activities to provide information used in the *Tank Farm Contractor Operation and Utilization Plan* (TFC O&UP) for evaluating various waste feed retrieval, delivery, and immobilization scenarios. The purpose of this attachment is to test and demonstrate the reliability of the models and calculations by performing a limited assessment of the HTWOS results for a selected waste processing event. The assessment documents a series of independently developed numerical results (sample calculations) that demonstrate traceability of source information used in HTWOS calculations, and confirm the definition and performance of some of the calculation methods (algorithms) embedded in the HTWOS. The results of the sample calculations and the HTWOS results are compared for significant differences that, if present, could indicate errors in the models and/or algorithms.

This attachment describes calculations used to transform the quantity of the waste in double-shell tank (DST) 241-AZ-101 into the quantities of immobilized low-activity waste (ILAW) and immobilized high-level waste (IHLW) projected by the HTWOS and reported in the TFC O&UP. DST 241-AZ-101 was selected for this assessment because it is a source of both low-activity waste (LAW) and high-level waste (HLW) feed, and thus allows the preparation of sample calculations for both types of waste processes. This assessment presented in this attachment is limited in two key ways:

- For brevity's sake, sample calculations are not provided for all of the tank constituents. Only a few of the most significant parameters have been included out of more than one hundred chemicals and radionuclides modeled in the HTWOS.
- DST 241-AZ-101 waste processing is relatively straightforward and does not require use of all the process models and algorithms that may be employed by the HTWOS. DST 241-AN-104 calculations are significantly more complex due to multiple waste dissolution, chemical partitioning, and blending steps. A description of the HTWOS steps for DST 241-AN-104 is provided in the TFC O&UP based on the specific parameter and stream code names used in the HTWOS.

The limited assessment provided in this attachment shows the effectiveness of using sample calculations to confirm reliability of the TFC O&UP results. This particular assessment also helps establish reliability of the HTWOS modeling and calculations for processing the DST 241-AZ-101 waste.

Summary of DST 241-AZ-101 Processing[2]

The current DST 241-AZ-101 tank waste consists of a layer of settled solids (sludge) overlain by a layer of liquid (supernate). Mixer pumps will be operated to prepare a waste slurry by mixing and suspending most of the settled solids in the liquid fraction. Most of the slurry will be pumped as combined waste feed Envelope B (LAW) and D (HLW) to the treatment and immobilization facility. The combined slurry will be separated by filtration into a LAW liquid fraction and a HLW solids fraction. The solids fraction will be washed, vitrified, and then poured into metal canisters to produce the IHLW product. The chemicals leached out of the solids in the washing process will be combined with the LAW liquid fraction. The combined LAW liquid waste will be vitrified and then poured into metal packages to produce the ILAW product.

Calculations (For Selected Waste Species)

1. Define Starting Total Inventory of Waste (Liquids plus Solids) in DST 241 AZ-101

Waste species	Total inventory
Total Sodium (Na)	3.54×10^5 kg
Total Aluminum (Al)	4.90×10^4 kg
Total Iron (Fe)	2.32×10^4 kg
Total Zirconium (Zr)	8.22×10^3 kg

Source: Tank Waste Information Network System (TWINS), available via Internet at http://twins.pnl.gov:8001/twins.htm; also reported in TFC O&UP, Vol. II, Table B1-2.

2. Define Partitioning of Waste Species Between Liquid and Solid Phases

Waste species	Total quantity in liquids	Total quantity in solids*
Na	3.33×10^5 kg	2.10×10^4 kg
Al	3.23×10^4 kg	1.67×10^4 kg
Fe	3.50×10^1 kg	2.32×10^4 kg
Zr	—	8.22×10^3 kg

* Defined as in the sludge layer.

[2] The described waste treatment and immobilization activities are based on information provided through March 2000 by BNFL Inc. about anticipated in-plant processing activities. The treatment and immobilization steps modeled in the HTWOS are subject to change pending further BNFL Inc. process definition and facility design.

Source: TWINS; also reported in TFC O&UP, Vol. II, Tables B3-1 and B3-2

3. Calculate the Quantity of Solids Mobilized by Mixer Pumps

Equation 1
(Mobilization Factor)(Total Quantity in Solids) = (Quantity of Mobilized Solids)

Mobilization Factor = 0.9 (fraction of solids that can be mobilized by mixer pumps as currently designed is assumed to be 90% of total solids quantity)

Source: TFC O&UP, Vol. II, Appendix A, Assumption A7.14

Waste species	Calculation	Quantity of mobilized solids
Na	$(0.9)(2.10 \times 10^4$ kg)	1.89×10^4 kg
Al	$(0.9)(1.67 \times 10^4$ kg)	1.50×10^4 kg
Fe	$(0.9)(2.32 \times 10^4$ kg)	2.09×10^4 kg
Zr	$(0.9)(8.22 \times 10^3$ kg)	7.40×10^3 kg

4. Calculate Quantity of Delivered Solids (Fraction of Mobilized Solids That Are Transferred to BNFL Inc.)

Equation 2
[(Starting Waste Volume – Ending Waste Volume)/(Starting Waste Volume)](Quantity of Mobilized Solids) = (Quantity of Delivered Solids)

Starting Waste Volume = 3,024 m^3 (799,000 gal)

Source: Hanlon 1999

Ending Waste Height = 0.25 m (10 in.)

Source: TFC O&UP, Vol. II, Appendix A, Assumption A3.5

Waste Volume = (Waste Height)(Volume per Vertical Tank Meter)

Volume per Vertical Meter of 23-m (75-ft) Diameter Tank = 415 m^3/m (2,750 gal/in.)

Ending Waste Volume = (0.25)(415) = 104 m^3

[(Starting Waste Volume – Ending Waste Volume)/(Starting Waste Volume)] = (3,024 – 104)/(3,024) = 0.966

Waste species	Calculation	Quantity of delivered solids
Na	(0.966)(1.89×10^4 kg)	1.82×10^4 kg
Al	(0.966)(1.50×10^4 kg)	1.45×10^4 kg
Fe	(0.966)(2.09×10^4 kg)	2.02×10^4 kg
Zr	(0.966)(7.40×10^3 kg)	7.15×10^3 kg

5. Calculate Quantity of Solids After Washing (Fraction of Delivered Solids That Remain After Washing by BNFL Inc.)

Equation 3

(1 – Wash Factor)(Quantity of Delivered Solids) = (Quantity of Solids After Washing)

Waste species	Wash factor*
Na	7.89×10^{-1}
Al	1.31×10^{-1}
Fe	2.01×10^{-5}
Zr	0

* Fraction of waste species washed from the solids fraction, including interstitial liquid.

Source: TWINS; also reported in TFC O&UP, Vol. II, Tables B5-1 and B5-2

Waste species	Calculation	Quantity of solids after washing
Na	(1 – 0.789)(1.82×10^4)	3.84×10^3 kg
Al	(1 – 0.131)(1.45×10^4)	1.26×10^4 kg
Fe	(1 – 0.00002)(2.02×10^4)	2.02×10^4 kg
Zr	(1 – 0)(7.15×10^3)	7.15×10^3 kg

6. Calculate the Quantity of IHLW Glass Produced

There are two methods for calculating the quantity of IHLW glass produced. One method employs the Pacific Northwest National Laboratory's Glass Properties Model (see description in TFC O&UP, Vol. II, Appendix A, Assumption A7.13). This complex method is believed to more closely approximate expected IHLW glass quantities than the second method, which is defined in the ORP and BNFL Inc. contract (ORP 1999) (see Specification 1). The second method provides a more conservative (larger) estimate of IHLW glass quantities and entails a three step process:

a) Convert the quantity of solids that remains after washing by BNFL Inc. (elemental basis) to an oxides quantity (i.e., Na_2O, Al_2O_3, Fe_2O_3, and ZrO_2). For this waste, only Al_2O_3, Fe_2O_3, and ZrO_2 are important. These conversions are presented below in the *Equation 4* calculations.

b) For each component (or sum of components) in Specification 1 of the ORP and BNFL Inc. contract (ORP 1999) (see contract Table TS-1.1), divide the oxides quantity (calculated in step a), above) by the corresponding limiting factors for waste loading (shown in Table TS-1.1 and referred to as the maximum weight fraction in IHLW glass) to determine the projected IHLW glass quantity. These projections are presented below in the *Equation 5* calculations.

c) Identify the component or sum that results in the largest projected quantity of IHLW glass. This quantity is used for future calculations as the (more conservative) quantity of IHLW glass produced. This largest quantity value is identified below after the calculations.

<u>*Equation 4*</u> [(Oxide Molecular Weight)/(Sum of Element Molecular Weight)](Quantity of Solids After Washing) = (Oxides Quantity)

Chemical	Molecular weight*
Al	26.97
Fe	55.85
Zr	91.22
Al_2O_3	101.94
Fe_2O_3	159.70
ZrO_2	123.22

* Reproduced in and available from various handbooks of chemistry and physics.

Chemical	Calculation	Oxides quantity
Al	$[(101.94)/(2)(26.97)](1.26 \times 10^4)$	2.38×10^4 kg (Al_2O_3)
Fe	$[(159.70)/(2)(55.85)](2.02 \times 10^4)$	2.89×10^4 kg (Fe_2O_3)
Zr	$[(123.22)/(91.22)](7.15 \times 10^3)$	9.66×10^3 kg (ZrO_2)
All		6.24×10^4 kg (combined)

Equation 5
(Oxide Quantity)/(Maximum Weight Fraction in IHLW Glass) = (Projected IHLW Glass Quantity)

Component	Maximum weight fraction in IHLW glass
Al_2O_3	0.11
Fe_2O_3	0.125
ZrO_2	0.10
$Al_2O_3 + Fe_2O_3 + ZrO_2$	0.21

Source: Table TS-1.1 of the ORP and BNFL Inc. contract (ORP 1999).

Component	Calculation	Projected IHLW glass quantity
Al_2O_3	2.38×10^4 / 0.11	2.16×10^5 kg
Fe_2O_3	2.89×10^4 / 0.125	2.31×10^5 kg
ZrO_2	9.66×10^3 / 0.10	9.66×10^4 kg
$Al_2O_3 + Fe_2O_3 + ZrO_2$	6.24×10^4 / 0.21	2.97×10^5 kg *

*This value is assumed to be the largest quantity of IHLW glass produced for subsequent calculation purposes. Note that this calculation agrees closely with the HTWOS value of 299 MT reported in the TFC O&UP, Vol. I, Table 4.1-1, Column 23, Batch Group 1. The two MT difference is accountable by the rounding of preceding calculations to two significant figures. The results show that "hand" calculations corroborate the data reported by the HTWOS and support its reliability.

7. Calculate the Quantity of IHLW Canisters Produced

Equation 6
(IHLW Glass Quantity)/(Average Glass Quantity per IHLW Canister) = (Number of IHLW Canisters)

Average Glass Volume in Canister = 1.15 m^3

Source: TFC O&UP, Vol. I, Section 4.1.2

Average Glass Density = 2.66 MT per m^3

Source: TFC O&UP, Vol. I, Section 4.1.2

Average Glass Quantity per IHLW Canister = (1.15 m^3) x (2.66 MT/m^3) x (1,000 kg/MT) = 3.06×10^3 kg

Calculation	Number of IHLW canisters
$(2.97 \times 10^5) / (3.06 \times 10^3)$	97 *

*Note that this calculation agrees closely with the HTWOS value of 98 canisters reported in the TFC O&UP, Vol. I, Table 4.1-1, Column 25, Batch Group 1. The one canister difference is accountable by the rounding of preceding calculations to two significant figures. The results show that "hand" calculations corroborate the data reported by the HTWOS and support its reliability.

8. Calculate the Quantity of Sodium in the Combined Liquid Fraction (LAW Feed from DST 241-AZ-101)

Equation 7
(Total Sodium) - (Sodium in Solids After Washing) = (Sodium Quantity in Liquid Fraction)

Total Sodium = 3.54×10^5 kg

Source: TWINS; also reported in O&UPTFC, Vol. II, Table B1-2 (See Step 1, above)

Sodium in Solids After Washing = 3.84×10^3 kg

Source: Calculated quantity for Sodium reported in Step 5, above.

Calculation	Sodium quantity in liquid fraction
$(3.54 \times 10^5) – (3.84 \times 10^3)$	3.50×10^5 kg

9. Calculate the Quantity of ILAW Glass Produced from the Combined Liquid Fraction (LAW Feed)

Equation 8
[(Sodium Quantity in Liquid Fraction) (Ratio of Sodium Oxide to Sodium)] / (Sodium Oxide Loading in Glass) = (ILAW Glass Quantity)

Ratio of Sodium Oxide to Sodium = 62 / 46 = 1.35

Source: Available from various handbooks of chemistry and physics.

Sodium Oxide Loading in Glass = 7.5 weight %

Source: TFC O&UP, Vol. II, Appendix A, Assumption A7.14

Calculation	ILAW glass quantity
$[(3.5 \times 10^5)(1.35)] / (0.075)$	6.30×10^6 kg

10. Calculate the Quantity of ILAW Packages Produced

Equation 9
(ILAW Glass Quantity)/(Average Glass Quantity per ILAW Package) = (Number of ILAW Packages)

Average Glass Quantity per ILAW Package = 6.0 MT = 6,000 kg

Source: TFC O&UP, Vol. I, Section 3.1.2

Calculation	Number of ILAW packages
$(6.3 \times 10^6) / (6.0 \times 10^3)$	1,050 *

*Note that this calculation includes only the sodium contribution from DST 241-AZ-101, and so it is less than the HTWOS value of 1,511 ILAW packages that is reported in the TFC O&UP, Vol. I, Table 3.1-1, Column 15, for Batch 2a/2b (this batch represents processing of supernates from both DST 241-AZ-101 and 241-AZ-102). Calculating sodium contributions from DST 241-AZ-102 in the same manner as described in Step 8, above, results in 153 MT (153,000 kg) of sodium being delivered from DST 241-AZ-102. Calculating the quantity of ILAW glass in the same manner as described in Step 9, above, results in 459 ILAW packages being produced from processing the DST 241-AZ-102 supernate. Adding the 1,050 ILAW packages from DST 241-AZ-101 supernate processing and the 459 ILAW packages from DST 241-AZ-102 supernate processing yields a total of 1,509 ILAW packages. The two package difference is accountable by the rounding of preceding calculations to two significant figures. The results show that "hand" calculations corroborate the data reported by the HTWOS and support its reliability.

11. Calculate the Units of LAW Delivered

Equation 10
(Total Sodium Quantity Delivered) (Equivalent Units per Metric Ton of Sodium) = (Units of LAW Delivered)

Total Sodium Quantity Delivered = 350 MT + 153 MT = 503 MT

Source: From calculations in Steps 8 and 10, above.

Envelope B Equivalent Units = 2.6 Units/MT

Source: ORP and BNFL Inc. contract (ORP 1999), Section 7.2.3 (b)

Calculation	Units of LAW delivered
(503) (2.6)	1,308 Units *

*Note that this calculation agrees with the HTWOS value of 1,308 Units reported in the TFC O&UP, Vol. I, Table 3.1-1, Column 11, Batch 2a/2b. The results show that "hand" calculations corroborate the data reported by the HTWOS and support its reliability.

12. Calculate the Quantity of ILAW Glass Produced

Equation 11
(Number of ILAW Packages) (Average Quantity of Glass per Package) = (Quantity of ILAW Glass)

Number of ILAW Packages = 1,509

Source: From calculations in Step 10, above.

Average Quantity of Glass per Package = 6.0 MT

Source: TFC O&UP, Vol. I, Section 3.1.2

Calculation	Quantity of ILAW glass
(1,509) (6.0)	9,054 MT *

*Note that this calculation is reasonably close to (within about 0.3% of) the HTWOS value of 9,080 MT reported in the TFC O&UP, Vol. I, Table 3.1-1, Column 13, Batch 2a/2b. The difference is accountable by the rounding of preceding calculations and differences in other calculations that have been carried forward to this step. The results show that "hand" calculations corroborate the data reported by the HTWOS and support its reliability.

13. Calculate the Volume of ILAW Glass Produced

Equation 12
(Quantity of ILAW Glass) / (Average ILAW Glass Density) = (Volume of ILAW Glass)

Quantity of ILAW Glass = 9,054 MT

Source: From calculations in Step 12, above.

Average ILAW Glass Density = 2.66 MT/m^3

Source: TFC O&UP, Vol. I, Section 3.1.2

Calculation	Volume of ILAW glass
(9,054) / (2.66)	3,404 m^3 *

*Note that this calculation is reasonably close to (within about 0.3% of) the HTWOS value of 3,414 m^3 reported in the TFC O&UP, Vol. I, Table 3.1-1, Column 14, Batch 2a/2b. The difference is accountable by the rounding of preceding calculations and differences in other calculations that have been carried forward to this step. The results show that "hand" calculations corroborate the data reported by the HTWOS and support its reliability.

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